US011504682B2

(12) **United States Patent**
Corti et al.

(10) **Patent No.: US 11,504,682 B2**
(45) **Date of Patent: Nov. 22, 2022**

(54) **MIXER BASE ASSEMBLY FOR MIXING VESSELS AND METHOD OF USE**

(71) Applicant: **Pall Corporation**, Port Washington, NY (US)

(72) Inventors: **Eric A. Corti**, Worcester, MA (US); **Timothy Keating**, Cambridge (GB); **Andrew J. Malloy**, Hertfordshire (GB)

(73) Assignee: **Pall Corporation**, Port Washington, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 117 days.

(21) Appl. No.: **16/724,539**

(22) Filed: **Dec. 23, 2019**

(65) **Prior Publication Data**

US 2021/0187456 A1 Jun. 24, 2021

(51) **Int. Cl.**

B01F 13/08	(2006.01)
B01F 15/00	(2006.01)
B01F 33/452	(2022.01)
B01F 35/21	(2022.01)

(52) **U.S. Cl.**

CPC ***B01F 33/452*** (2022.01); ***B01F 35/2132*** (2022.01); ***B01F 35/2133*** (2022.01)

(58) **Field of Classification Search**

CPC B01F 13/0818; B01F 13/0827; B01F 13/0872; B01F 15/00006; B01F 33/4532; B01F 33/452

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,882,113	A	3/1999	Binder
5,885,113	A	3/1999	Bricaud
8,328,410	B1	12/2012	Retamal

(Continued)

FOREIGN PATENT DOCUMENTS

CN	202876683	U	4/2013
CN	103945928	A	7/2014

(Continued)

OTHER PUBLICATIONS

European Patent Office, extended European Search Report in counterpart European Patent Application No. 20199155.1 dated Mar. 22, 2021.

(Continued)

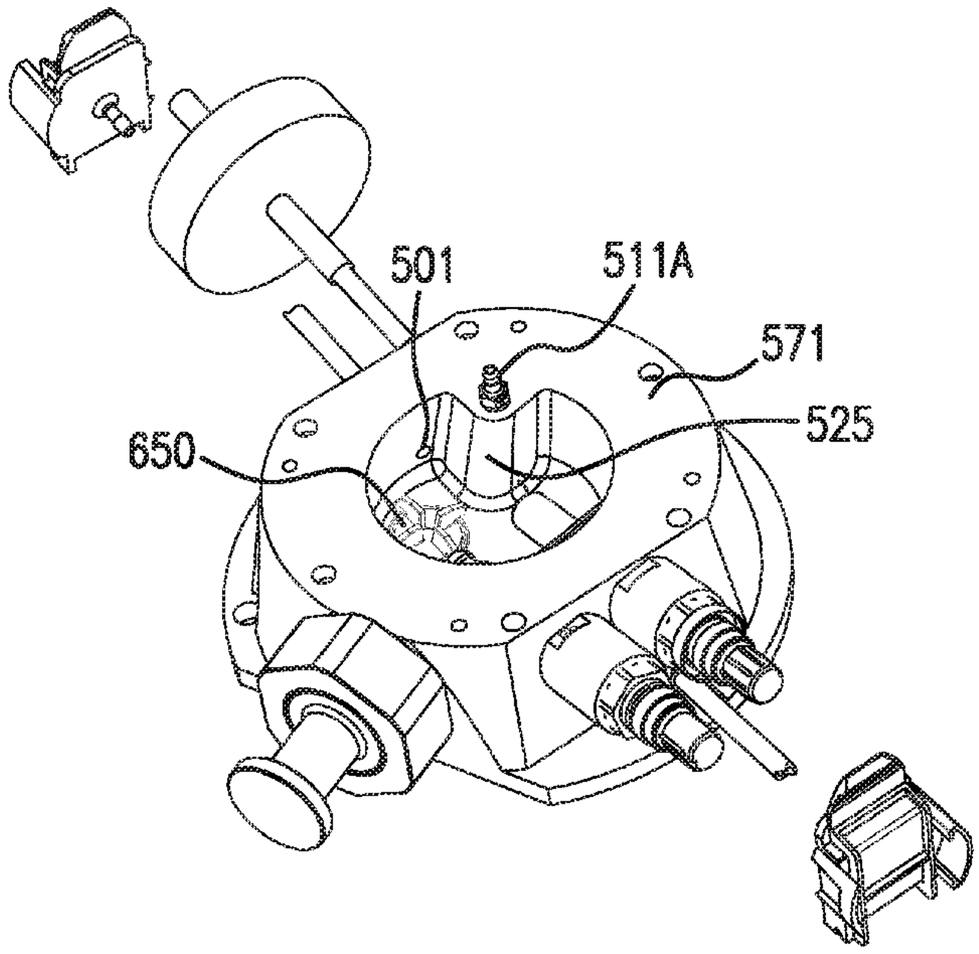
Primary Examiner — Elizabeth Insler

(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

(57) **ABSTRACT**

A mixer base assembly comprises (a) a body having an upper end including a mating face for mixing vessel connection; a lower end including a cavity; a first side wall, a second side wall, a third side wall, and a fourth side wall; an inlet port arranged in the first side wall; an outlet port arranged in the third side wall; a sampling port arranged in the fourth side wall; a probe port arranged in the third side wall; and, a fluid mixing chamber including a baffle and having a bottom wall; (b) an impeller seat arranged in the cavity in the lower end of the body; and, (c) a levitating magnetic impeller arranged in the impeller seat, the impeller comprising a magnet, a base, and at least two blades, wherein the blades extend above the bottom wall of the fluid mixing chamber into the fluid mixing chamber.

21 Claims, 17 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

8,469,585	B2 *	6/2013	Retamal	B01F 15/0261 366/149
9,784,163	B2	10/2017	Noren, IV et al.	
10,059,914	B2 *	8/2018	Watkins	C12M 41/32
10,920,185	B2	2/2021	Scibek et al.	
2015/0273414	A1	10/2015	Rozy et al.	
2017/0296988	A1	10/2017	Waggoner et al.	
2019/0168901	A1	6/2019	Mueggenborg et al.	
2021/0187457	A1	6/2021	Corti et al.	

FOREIGN PATENT DOCUMENTS

CN	104689737	A	6/2015
CN	107208519	A	9/2017
CN	109312284	A	2/2019
JP	2006-122785	A	5/2006
JP	2017-51947	A	3/2017
KR	10-1124220	B1	3/2012
KR	10-2015-0064698	A	6/2015
KR	10-2017-0029937	A	3/2017
WO	WO 2006/120945	A1	11/2006
WO	WO 2008/040568	A1	4/2008
WO	WO 2018/162174	A1	9/2018
WO	WO 2019/180710	A1	9/2019

OTHER PUBLICATIONS

Intellectual Property Office of Singapore, Search Report issued in counterpart Singapore Patent Application No. 10202009863W, dated Sep. 1, 2021.

Japanese Patent Office, Office Action in counterpart Japanese Patent Application No. 2020-167106, dated Oct. 19, 2021.

Canadian Intellectual Property Office, Office Action issued in Canadian Patent Application No. 3,099,502, dated Feb. 21, 2022.

"LevMixer® System", Pall Biotech, pp. 1-5 (2018).

Ondrey, "Alfa Laval Launches Levitating Mixer", *Chemical Engineering*, pp. 1-2, (Nov. 9, 2010).

Korean Intellectual Property Office, Office Action issued in counterpart Korean Patent Application No. 10-2020-0149066, dated May 11, 2022.

China National Intellectual Property Administration, Office Action issued in counterpart Chinese Patent Application No. 202011251665.1, dated Jun. 27, 2022.

* cited by examiner

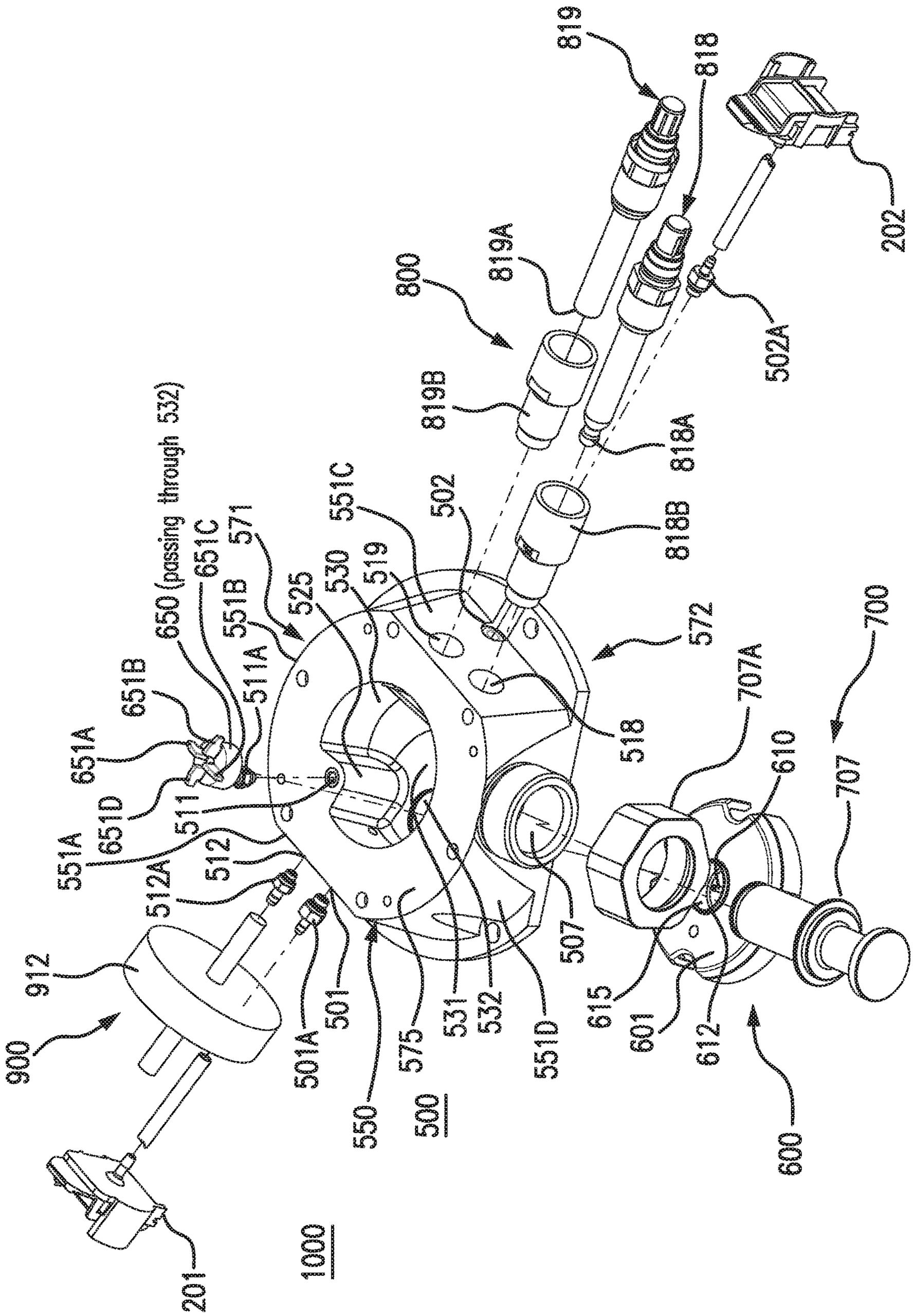

819
818
800
819A
202
502A
819B
818A
818B
650 (passing through 532)
651C
571
551B
551C
502
525
530
519
651B
651A
651D
511A
572
518
707A
610
700
707
512
512A
511
912
900
501A
501
550
575
531
532
551D
507
615
601
612
600
1000
500
201

FIG. 1

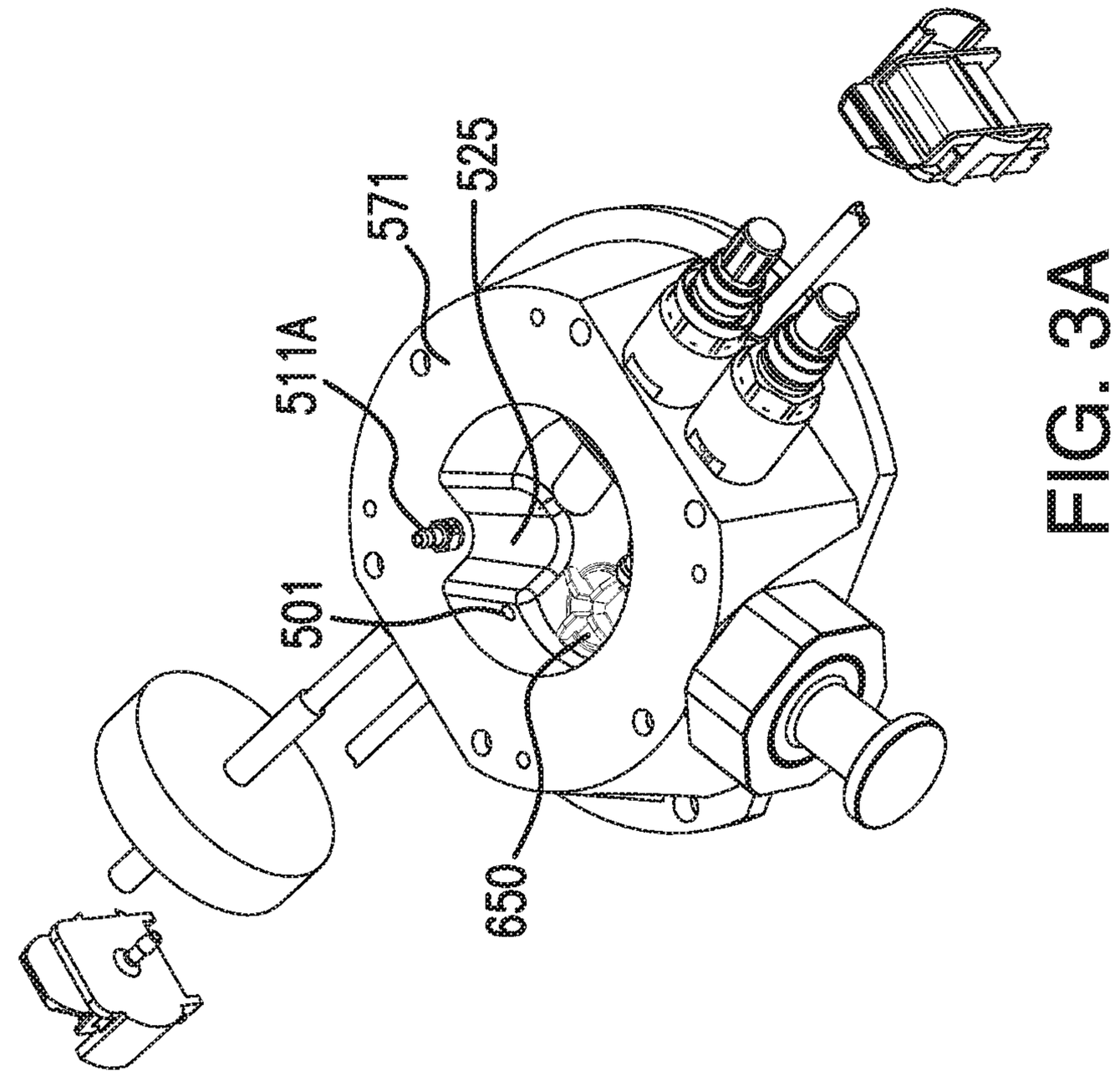


FIG. 3A

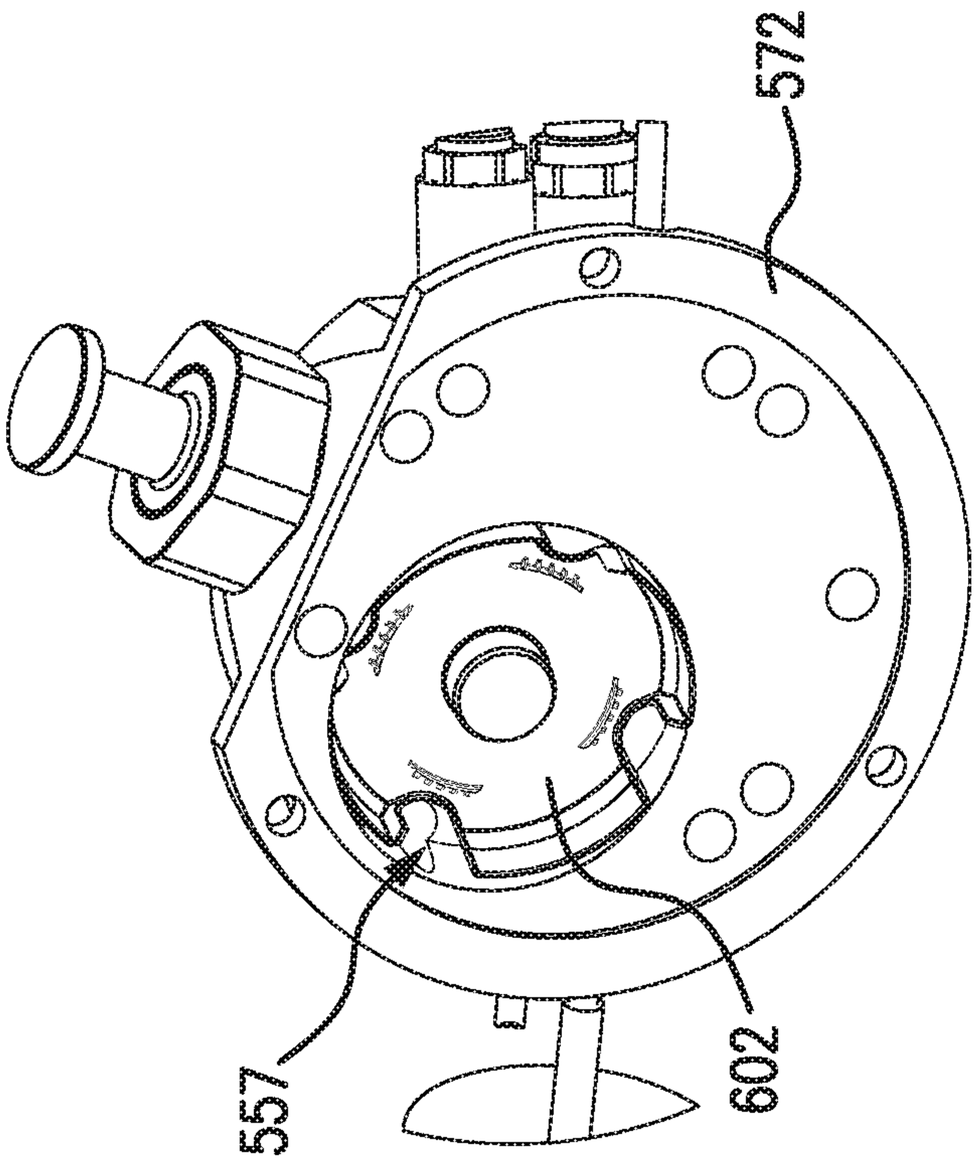


FIG. 2

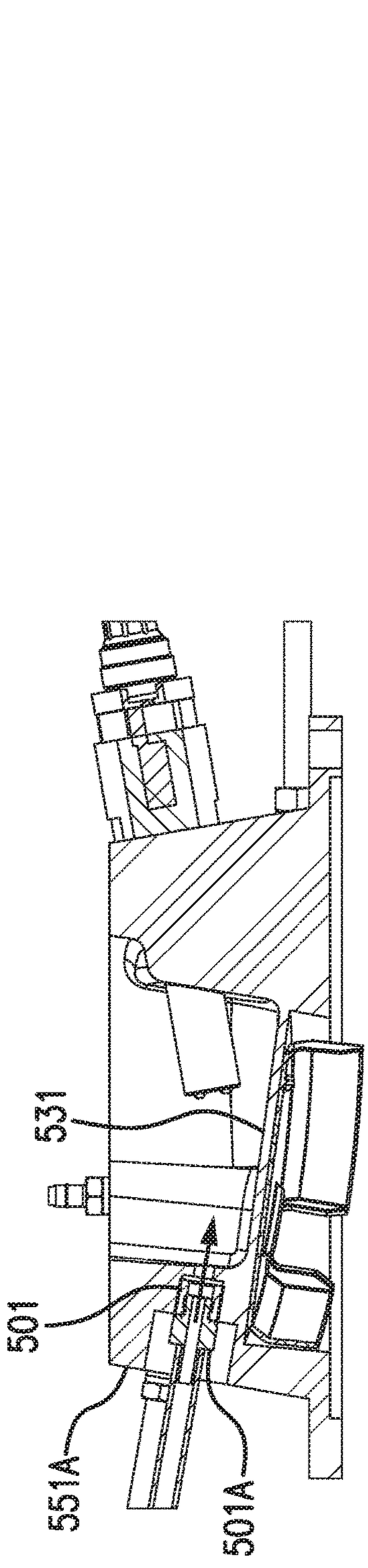


FIG. 3B

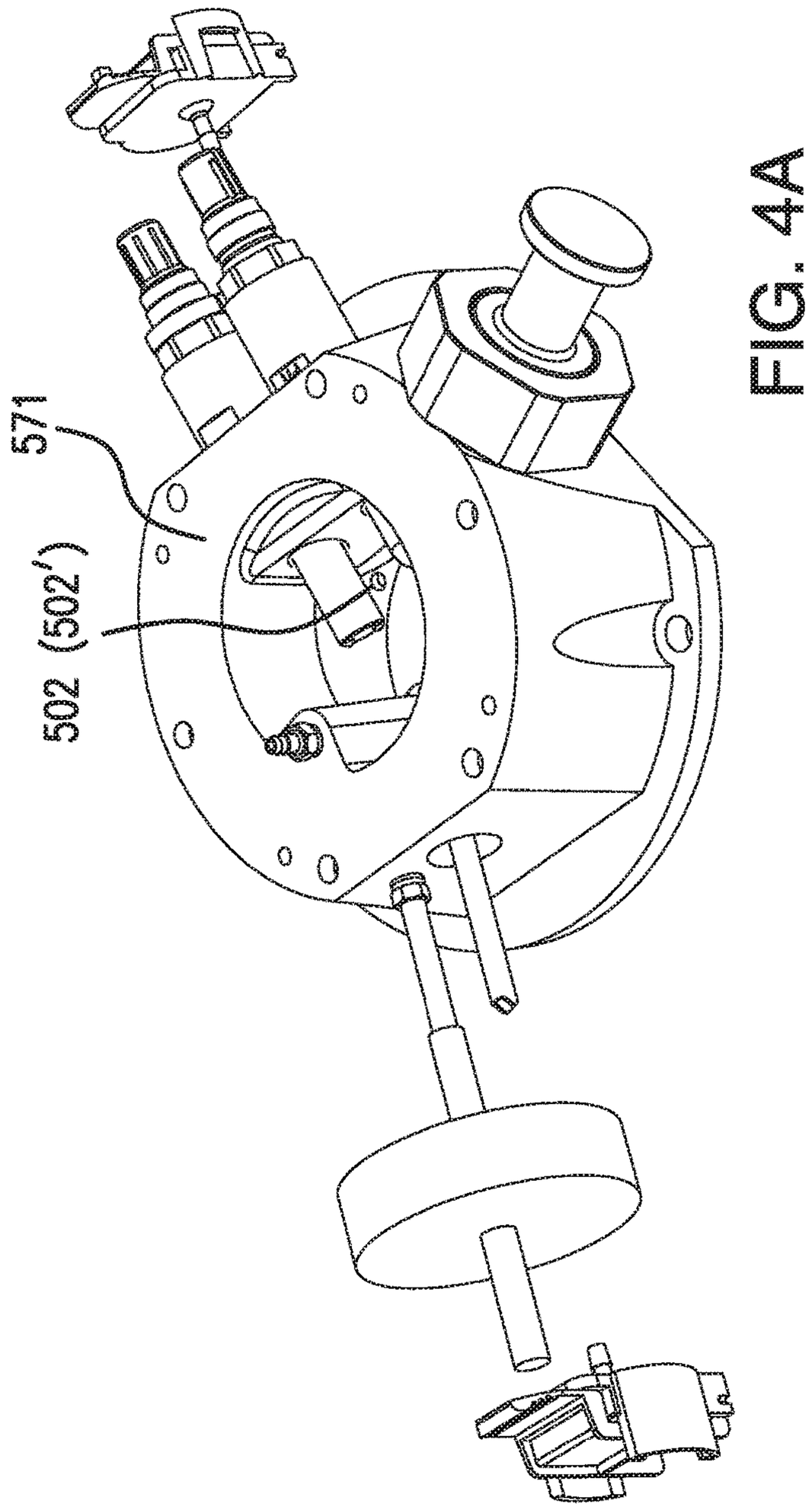


FIG. 4A

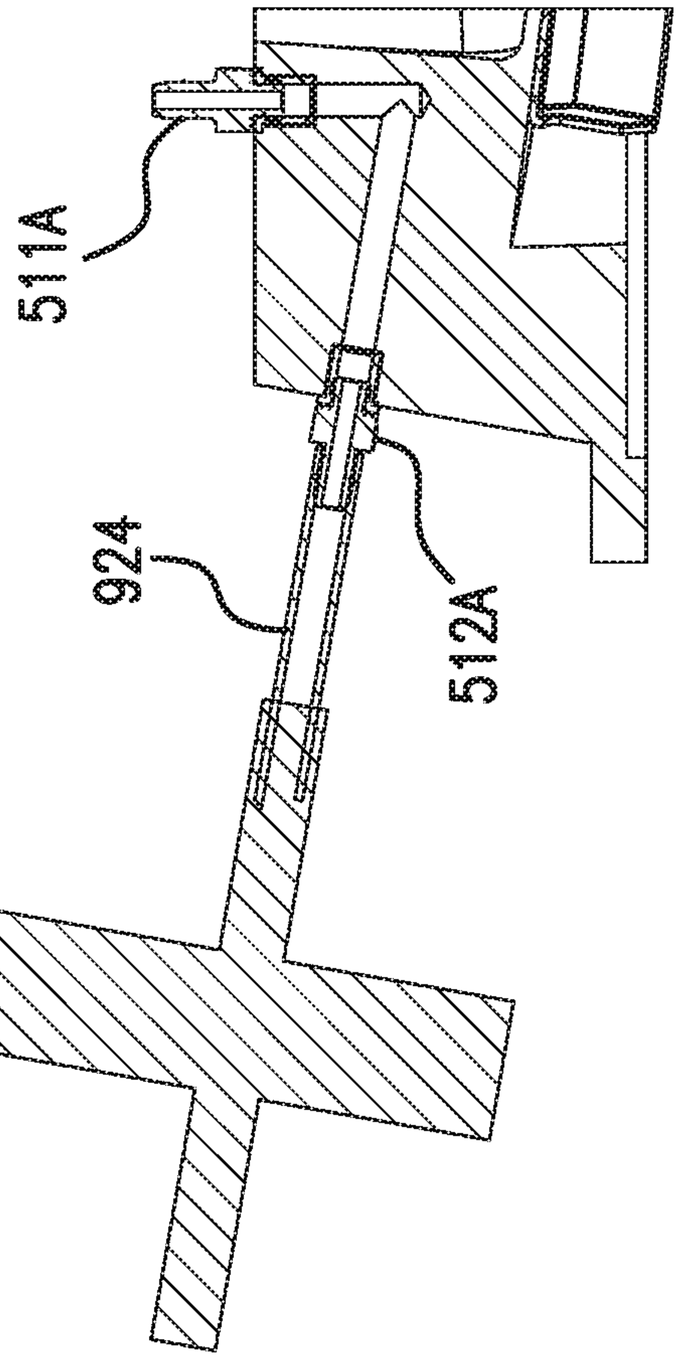


FIG. 6

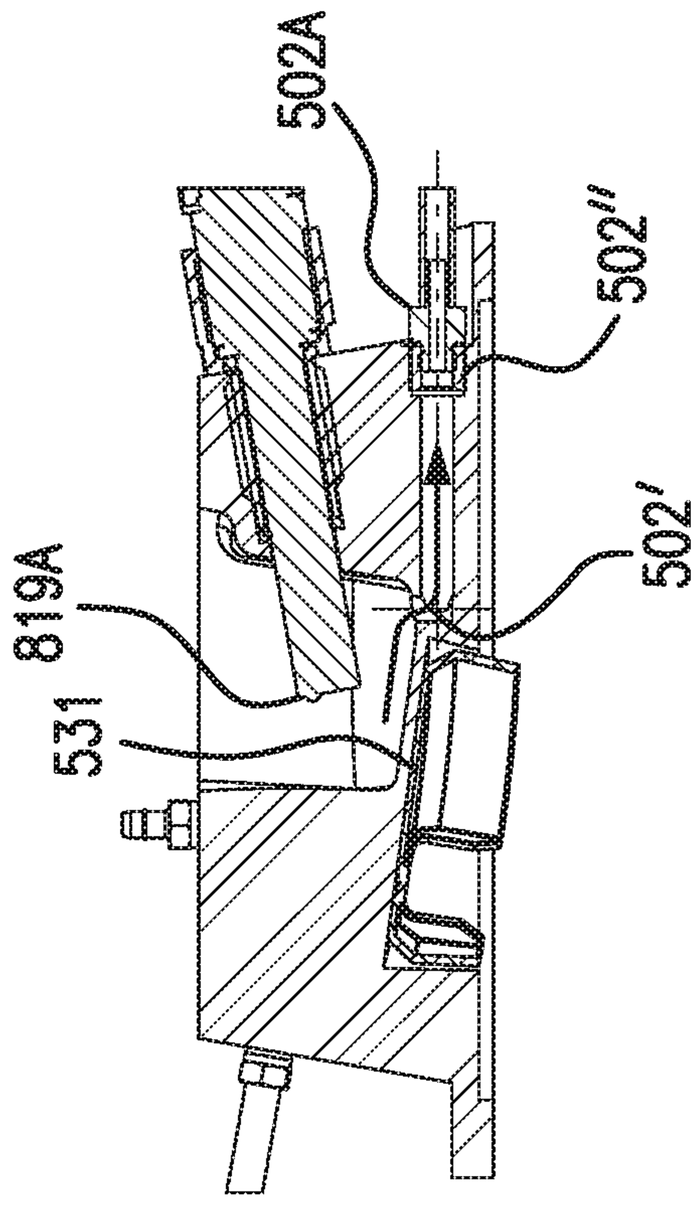


FIG. 4B

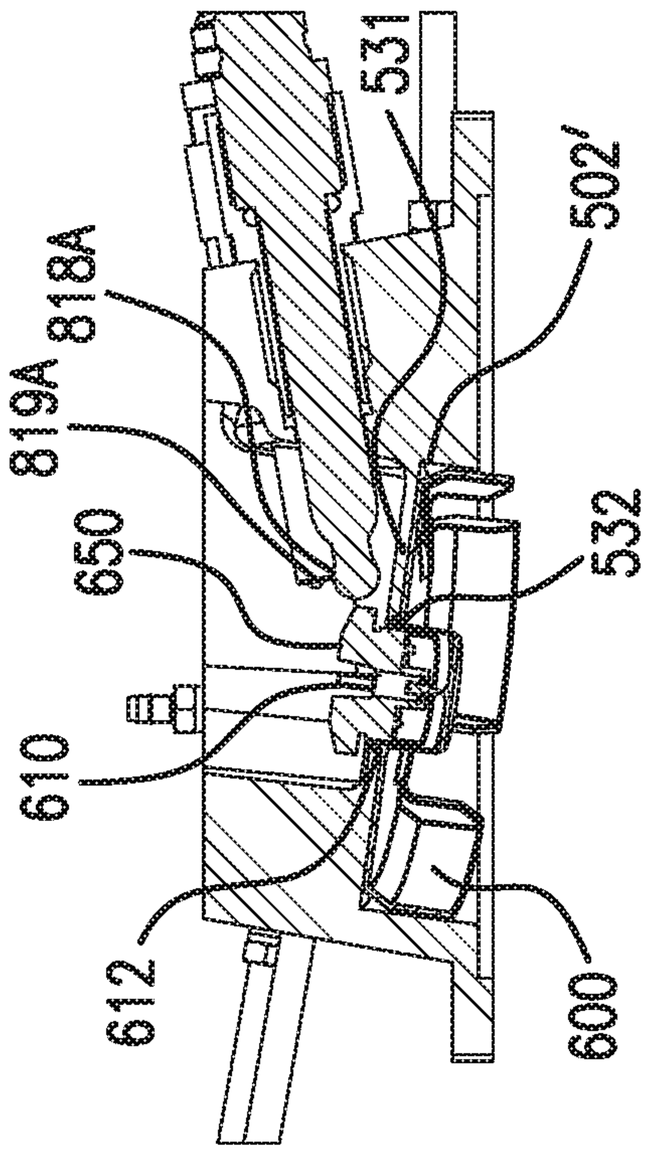


FIG. 5

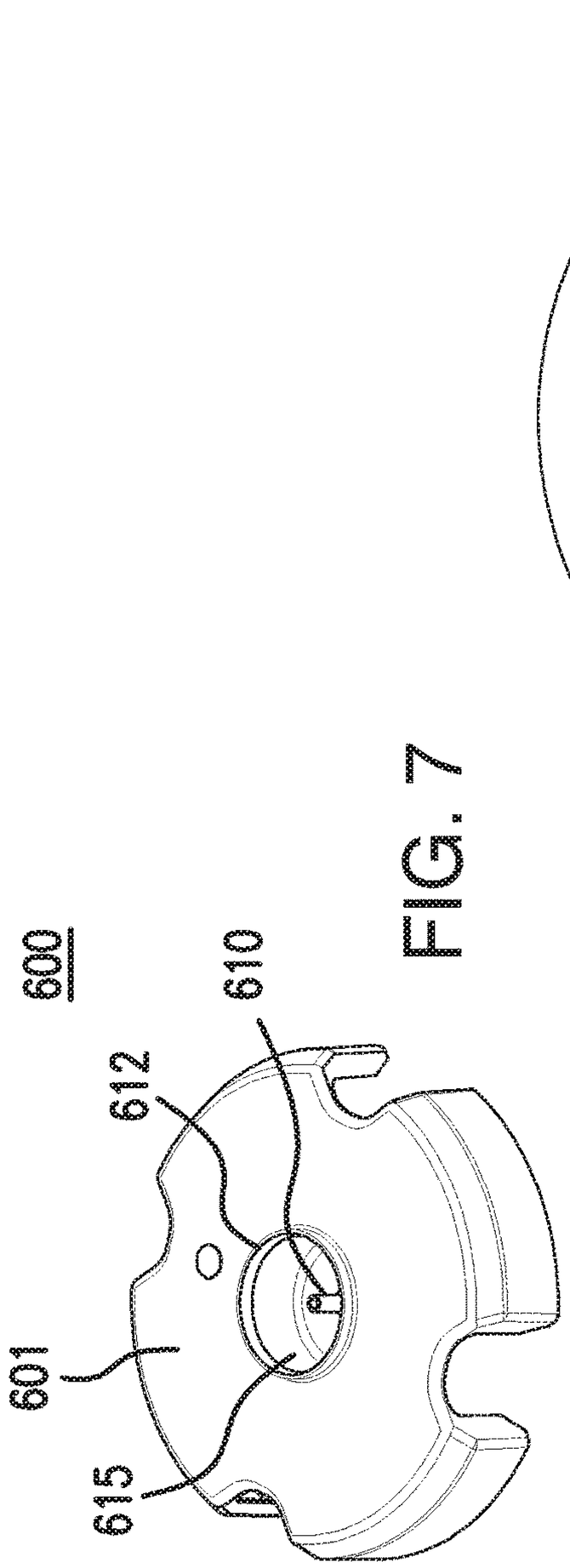


FIG. 7

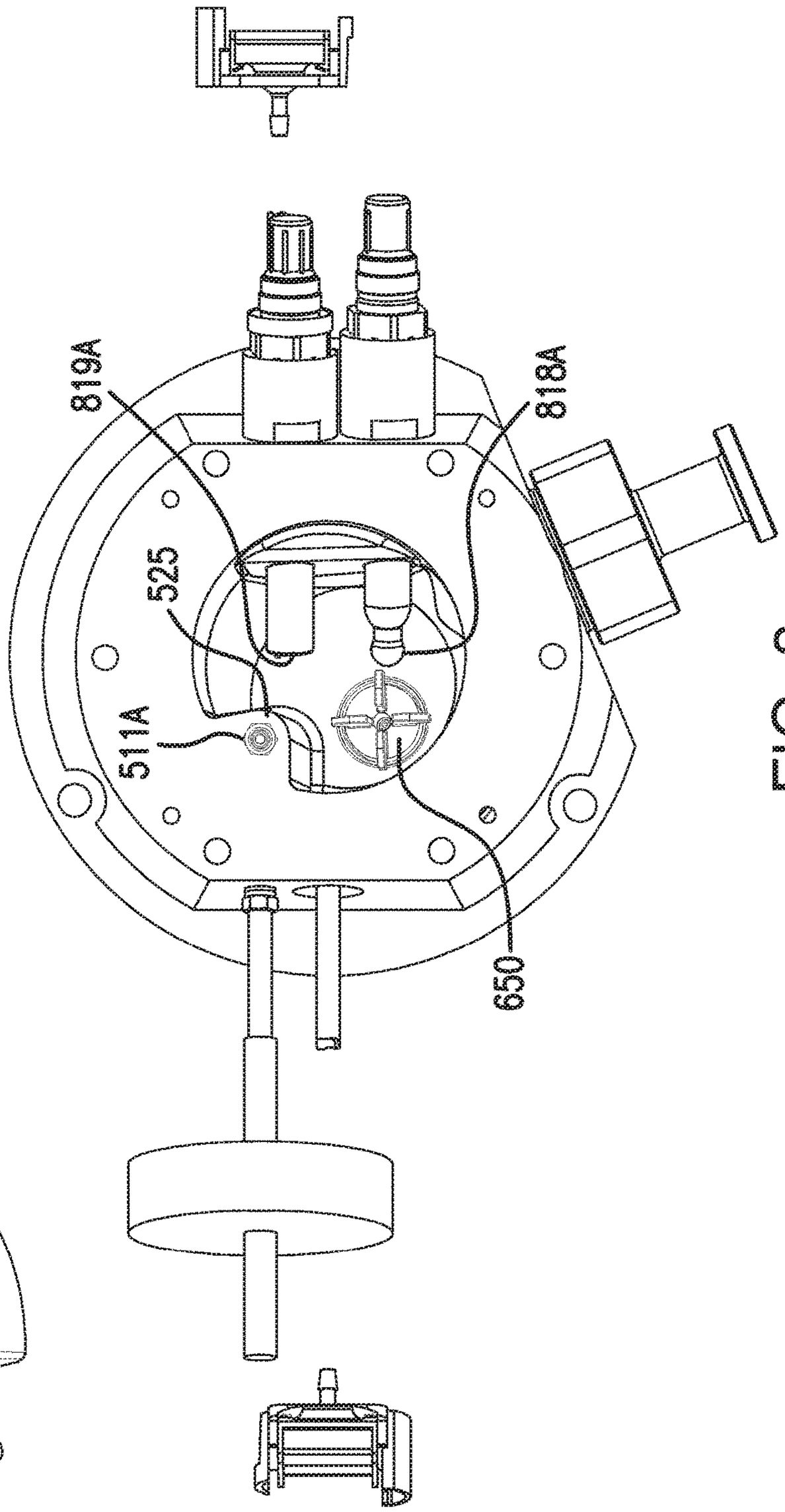


FIG. 8

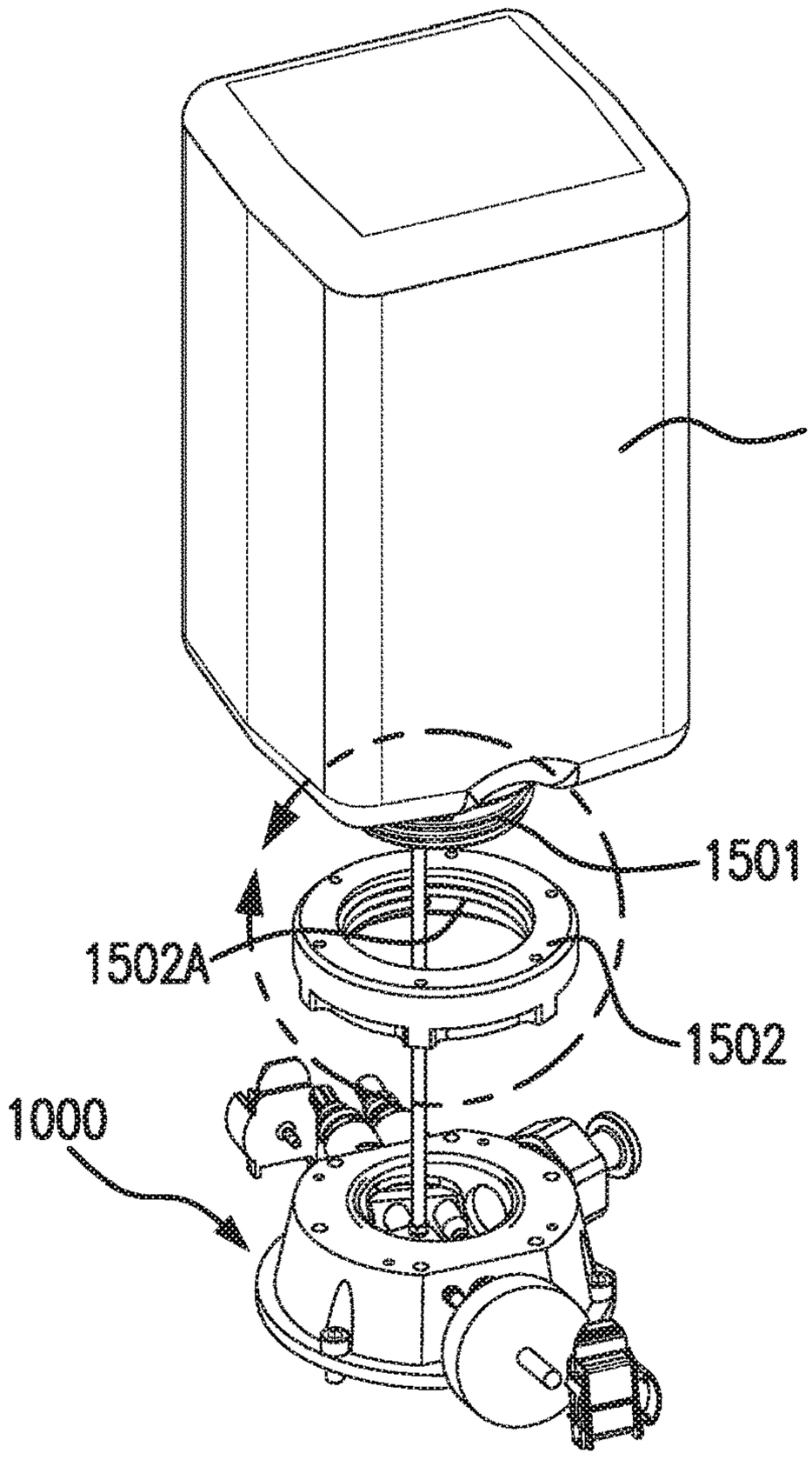


FIG. 9A

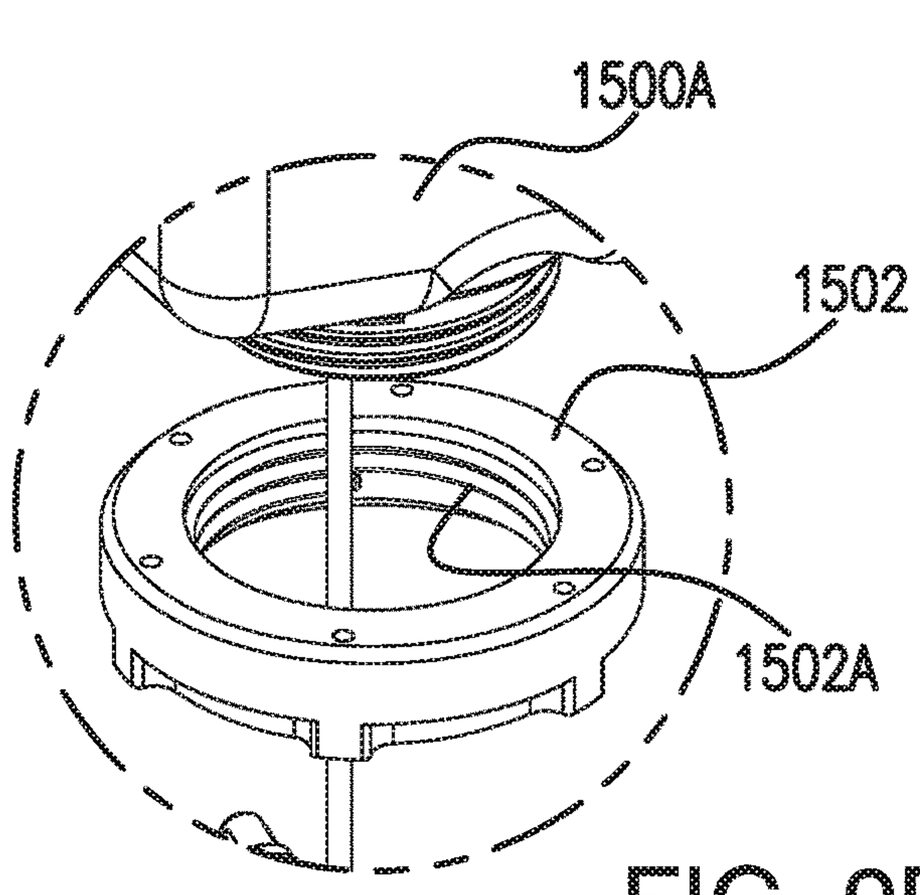


FIG. 9B

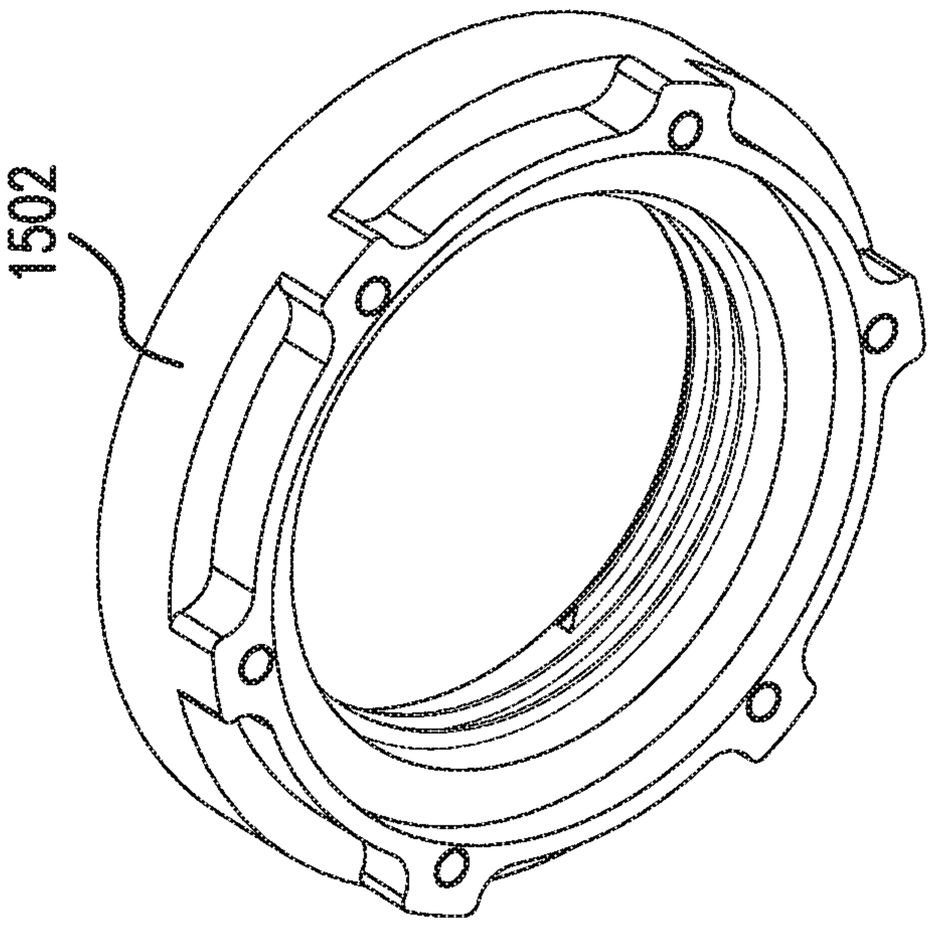


FIG. 6D

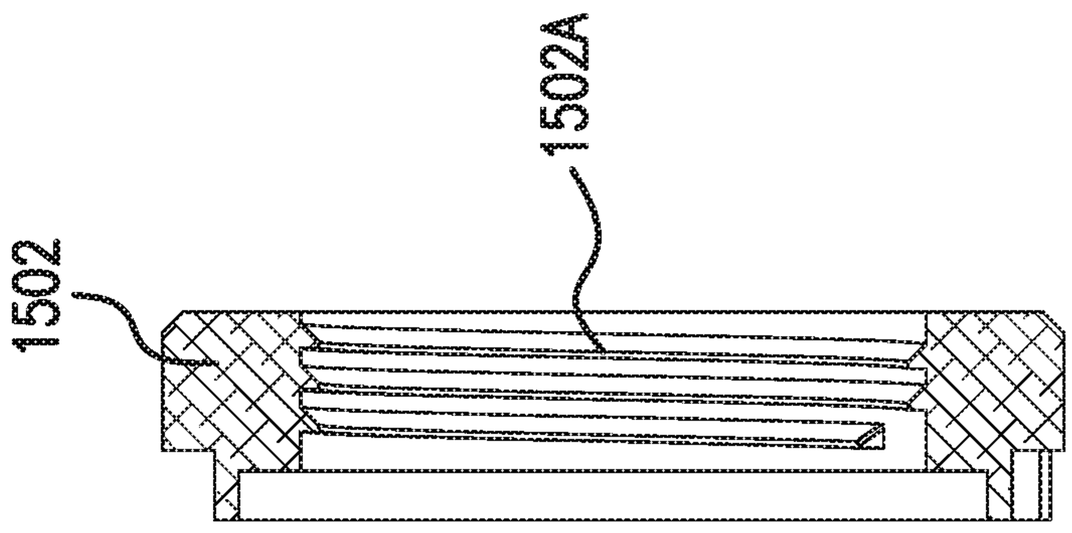


FIG. 6C

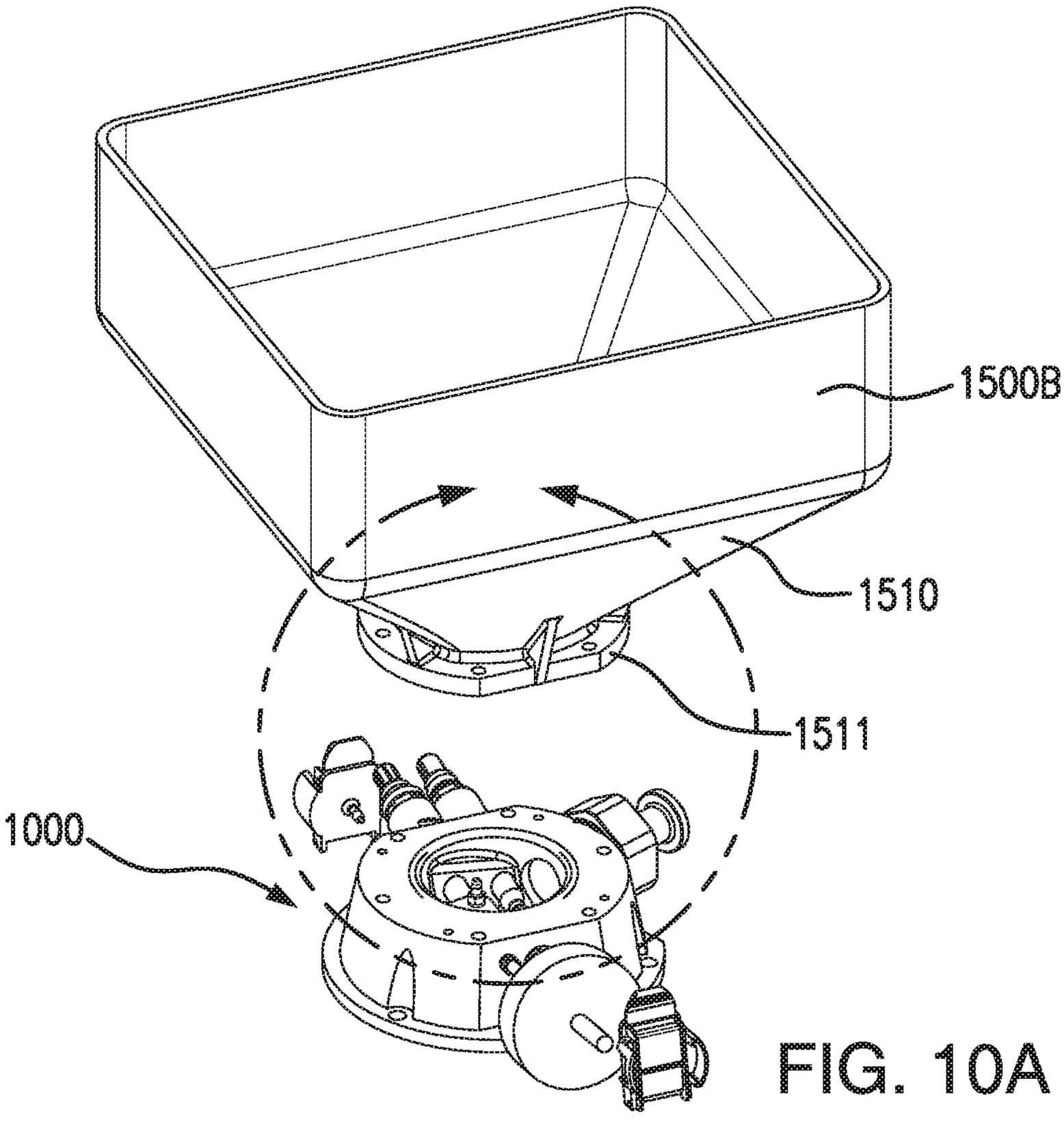


FIG. 10A

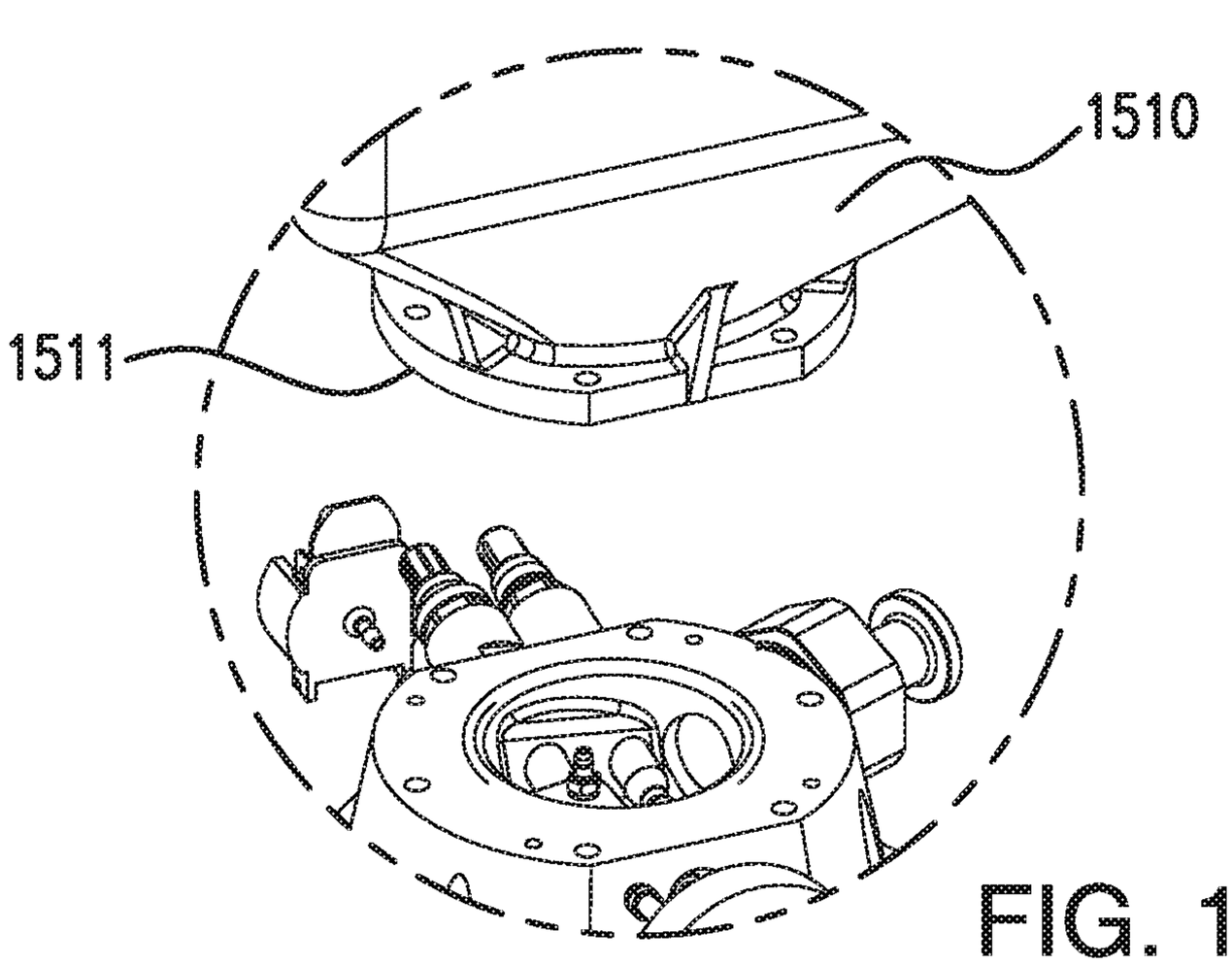


FIG. 10B

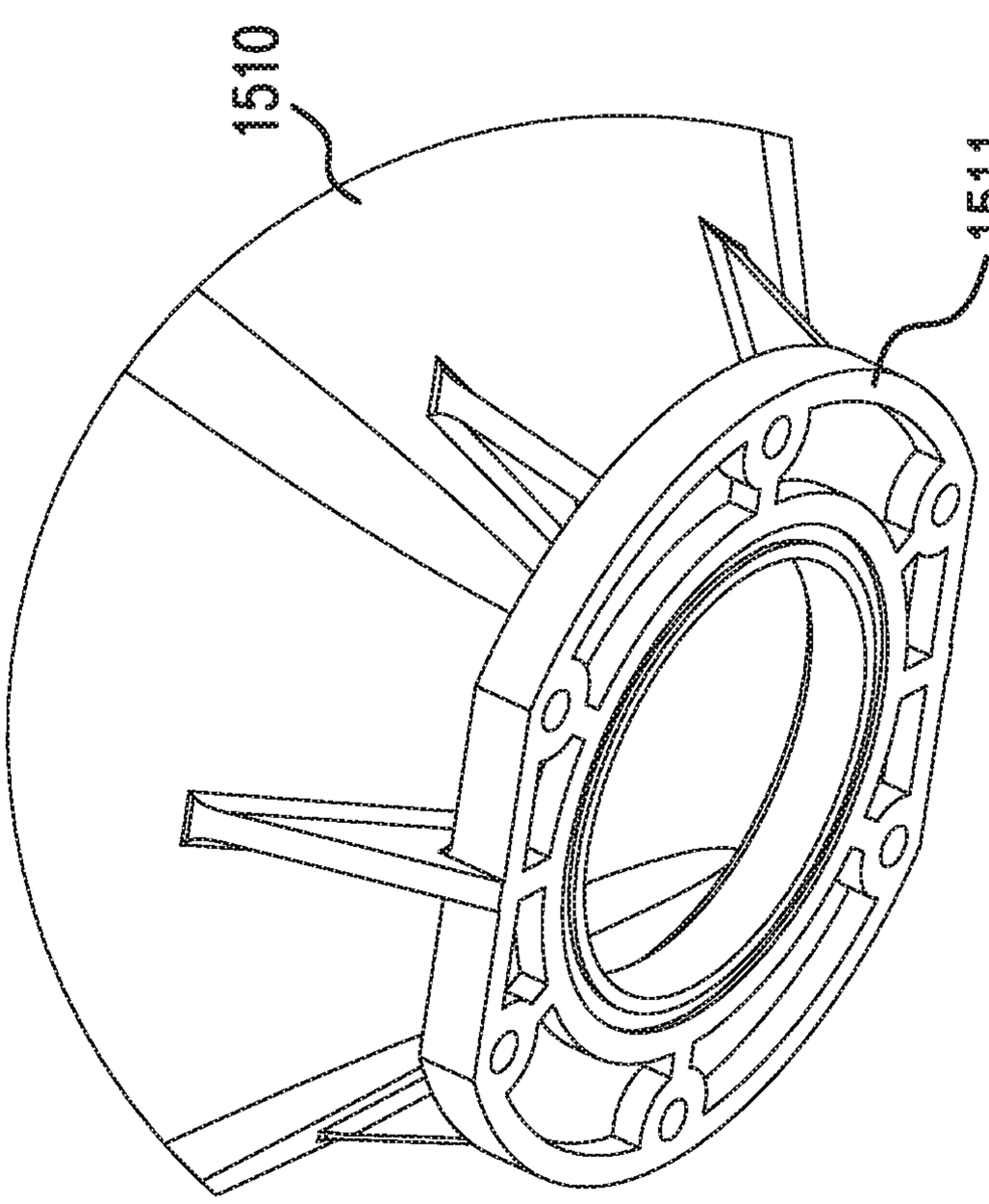


FIG. 10C

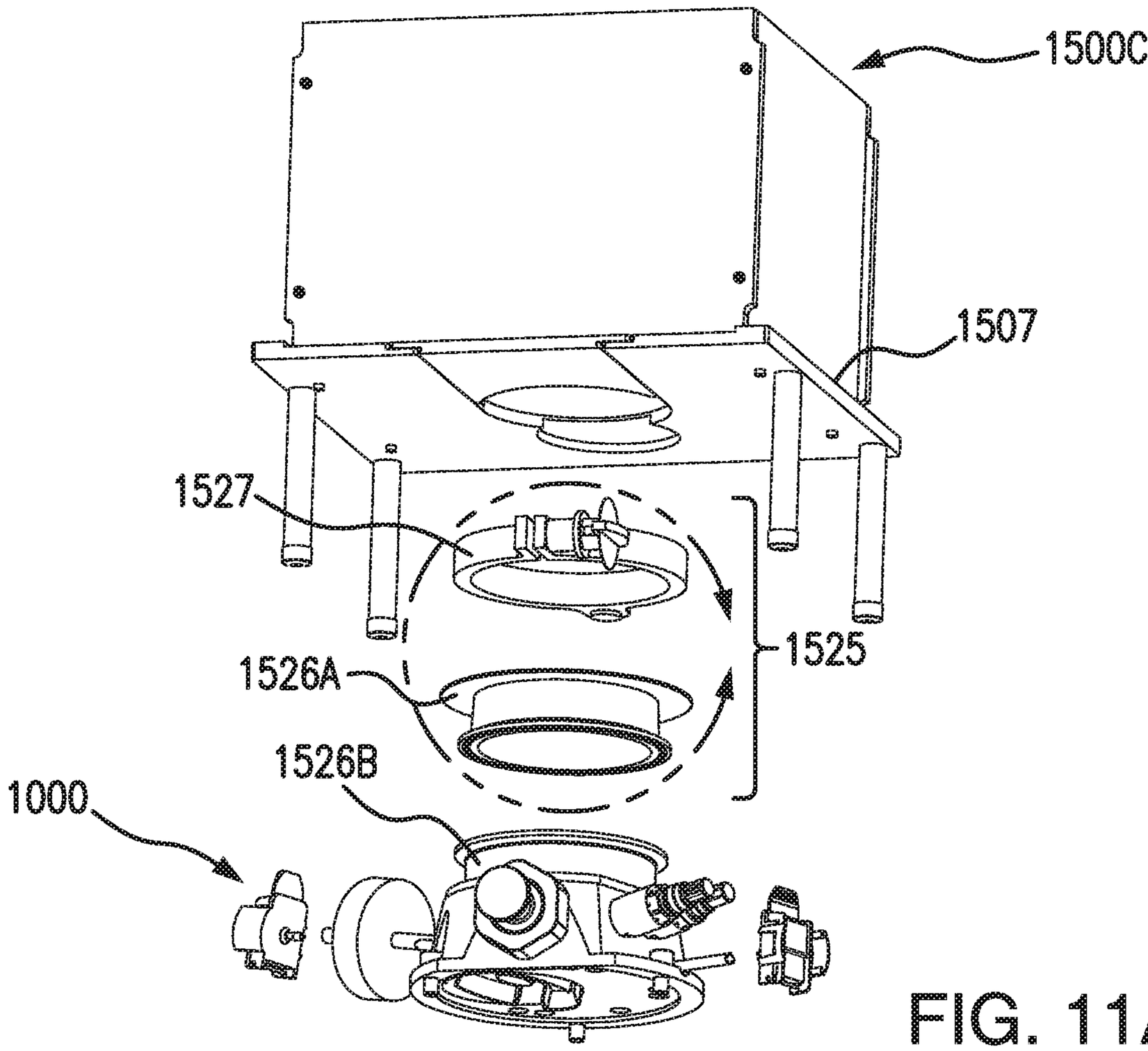


FIG. 11A

FIG. 11B

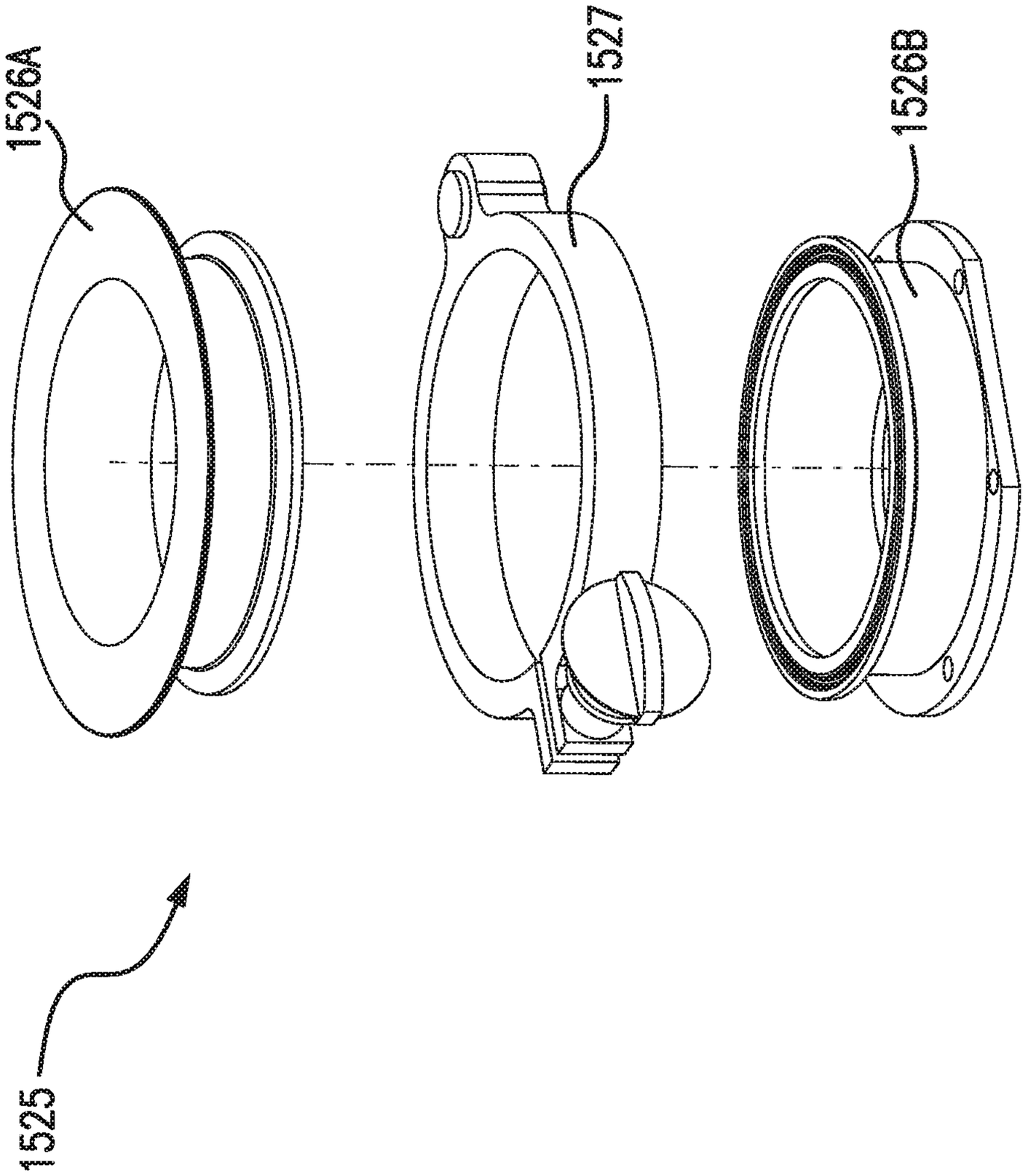


FIG. 1C

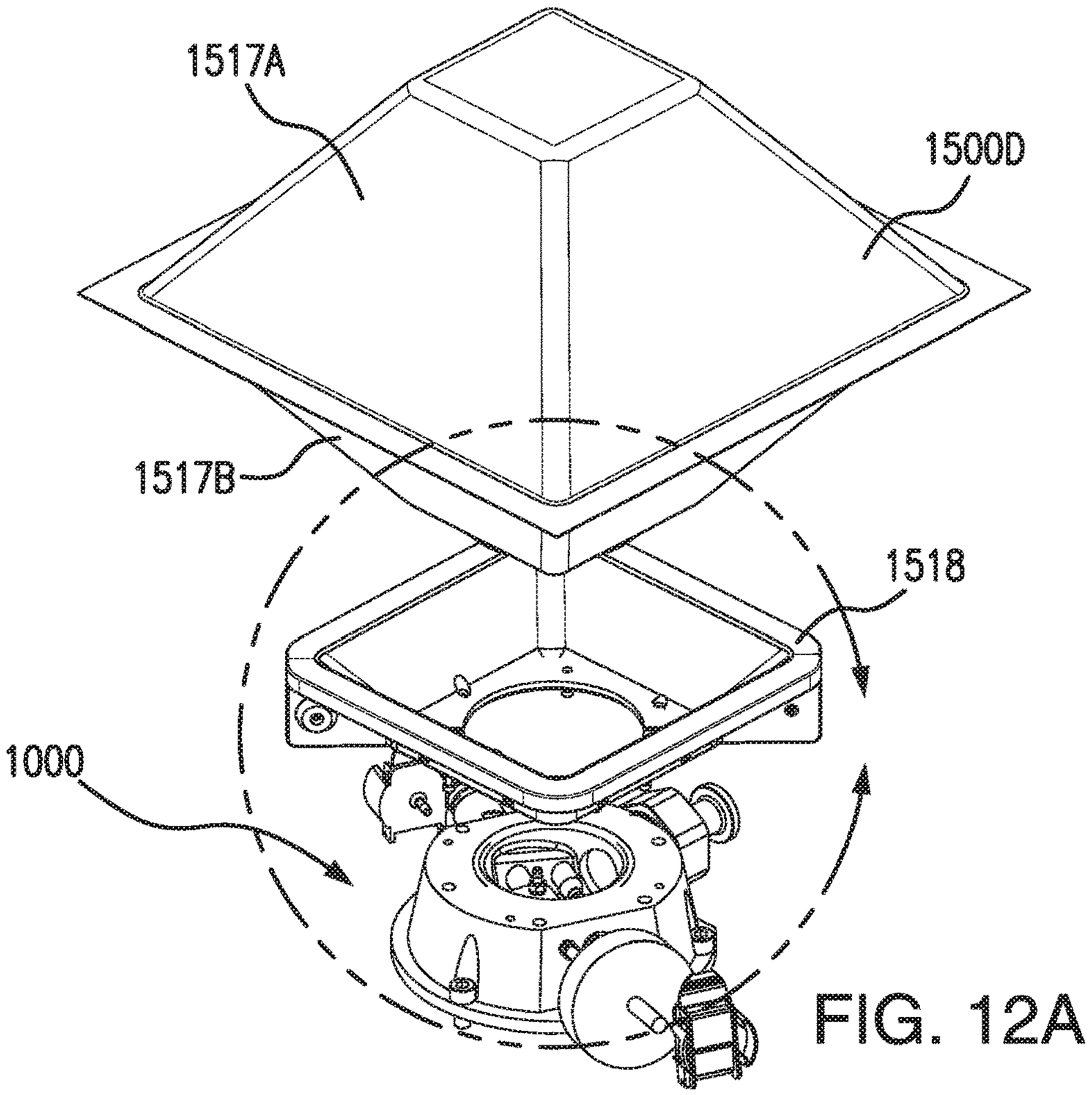


FIG. 12A

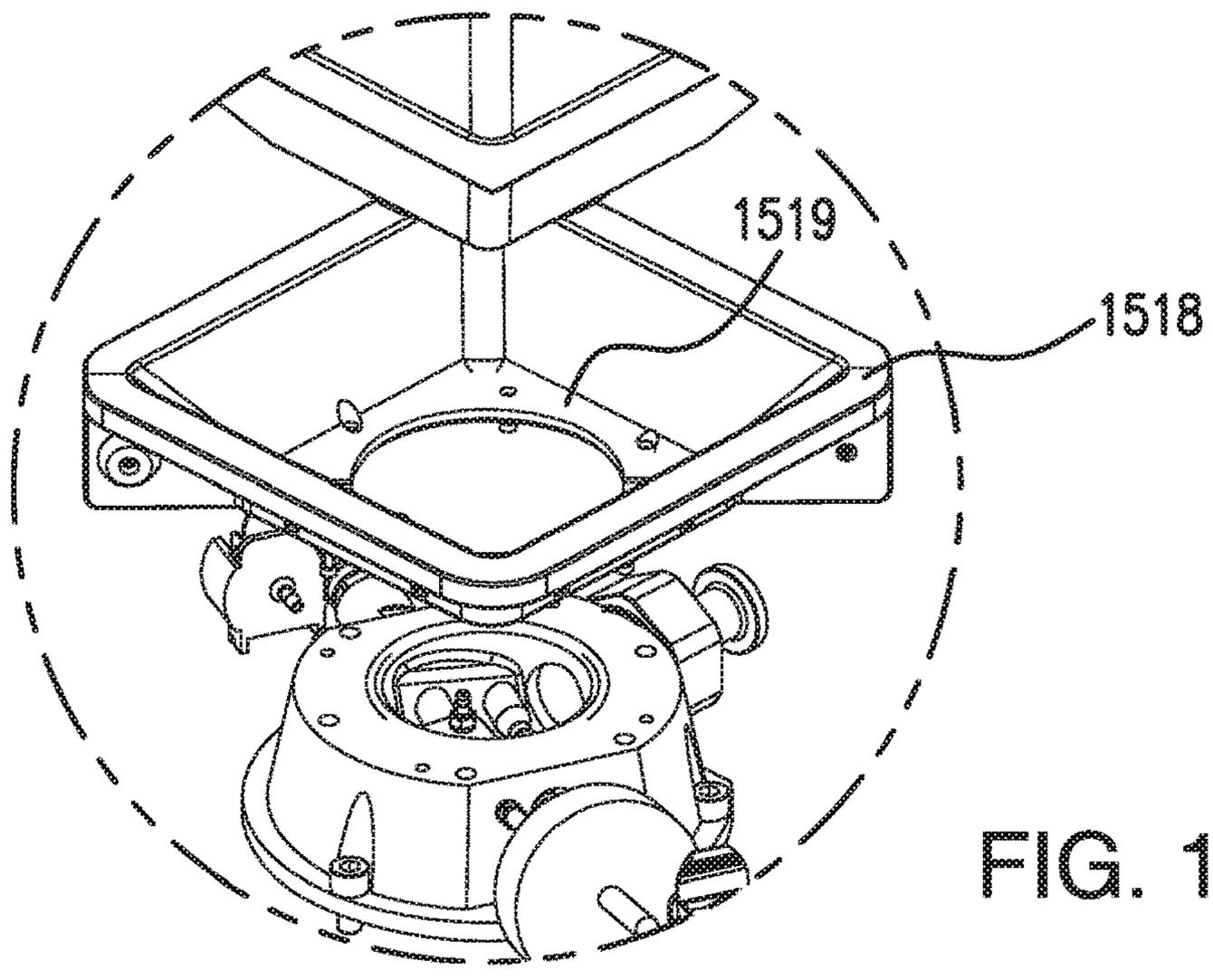


FIG. 12B

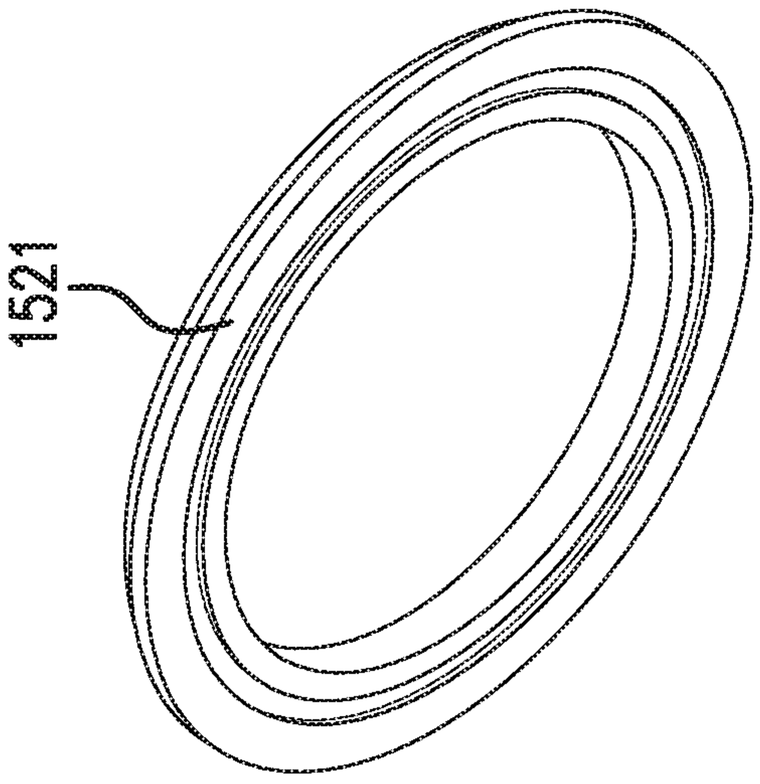


FIG. 12D

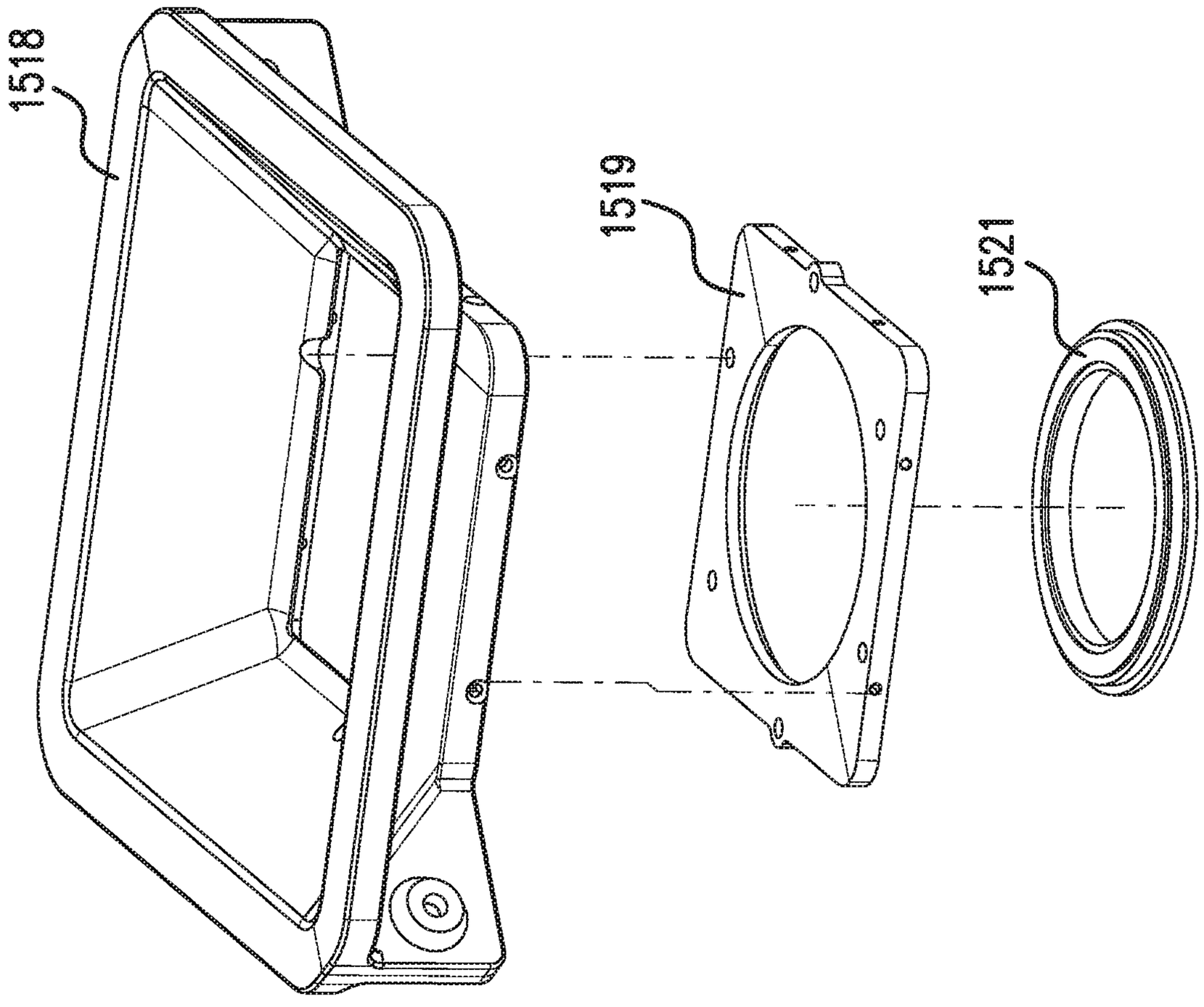


FIG. 12C

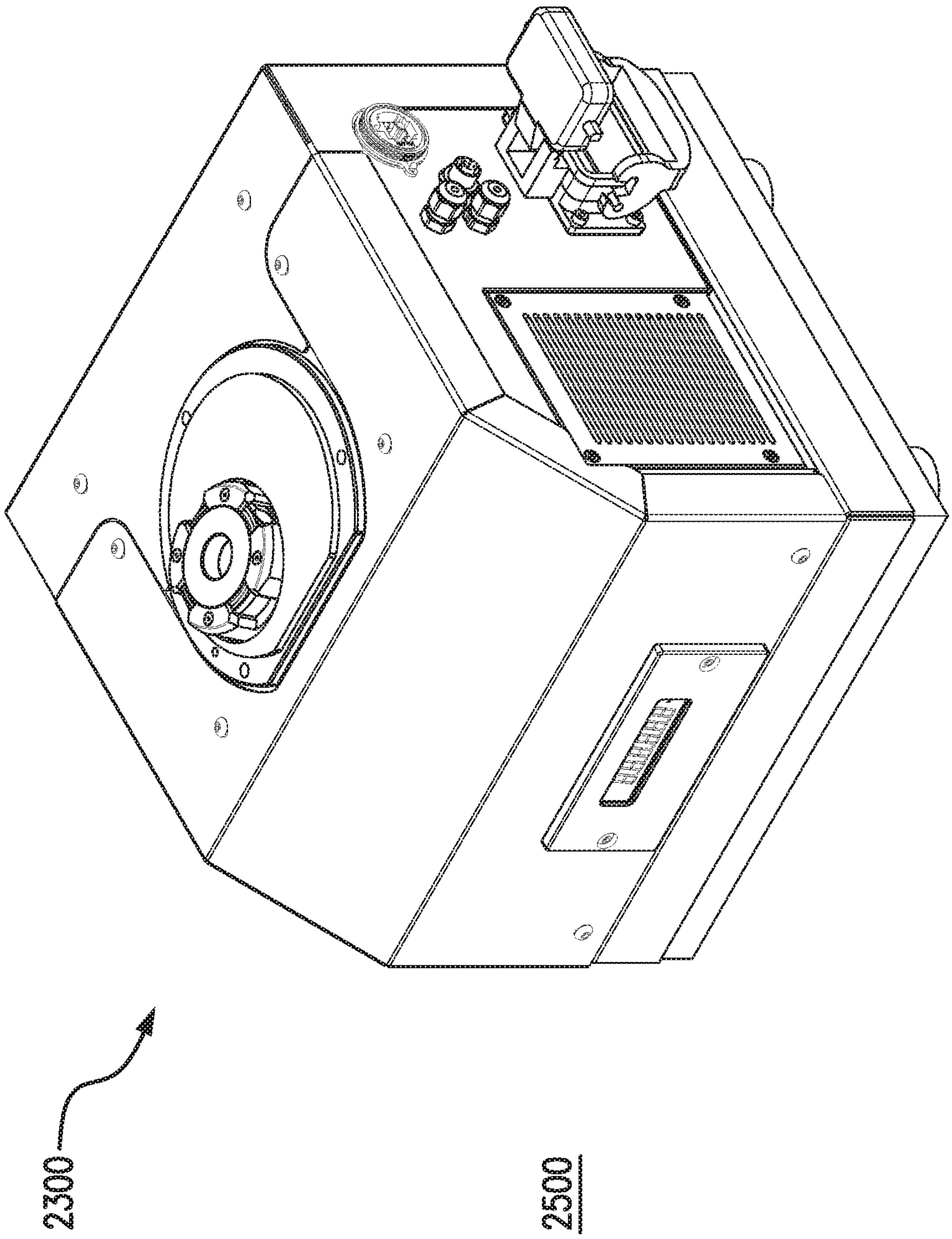


FIG. 13A

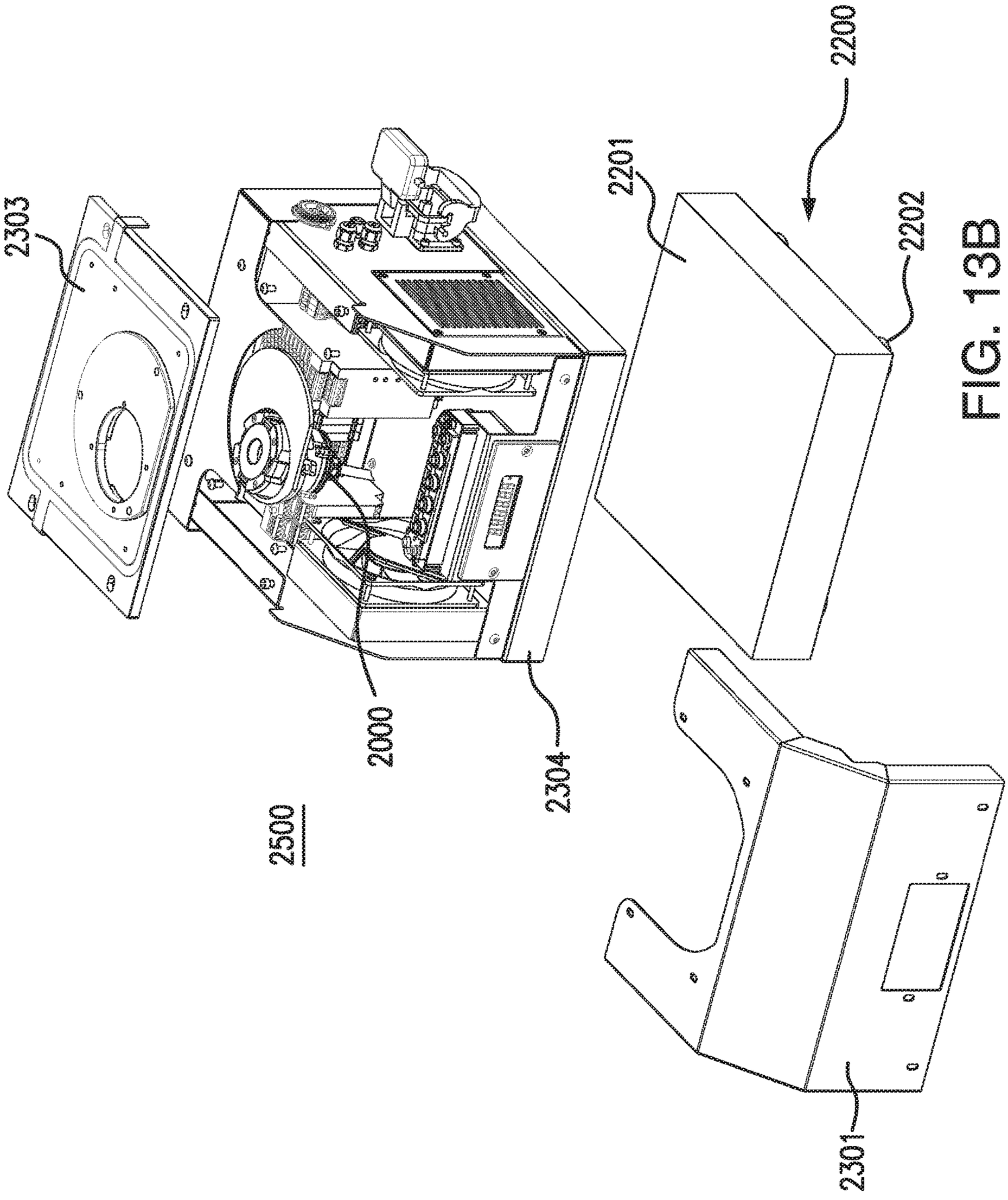


FIG. 13B

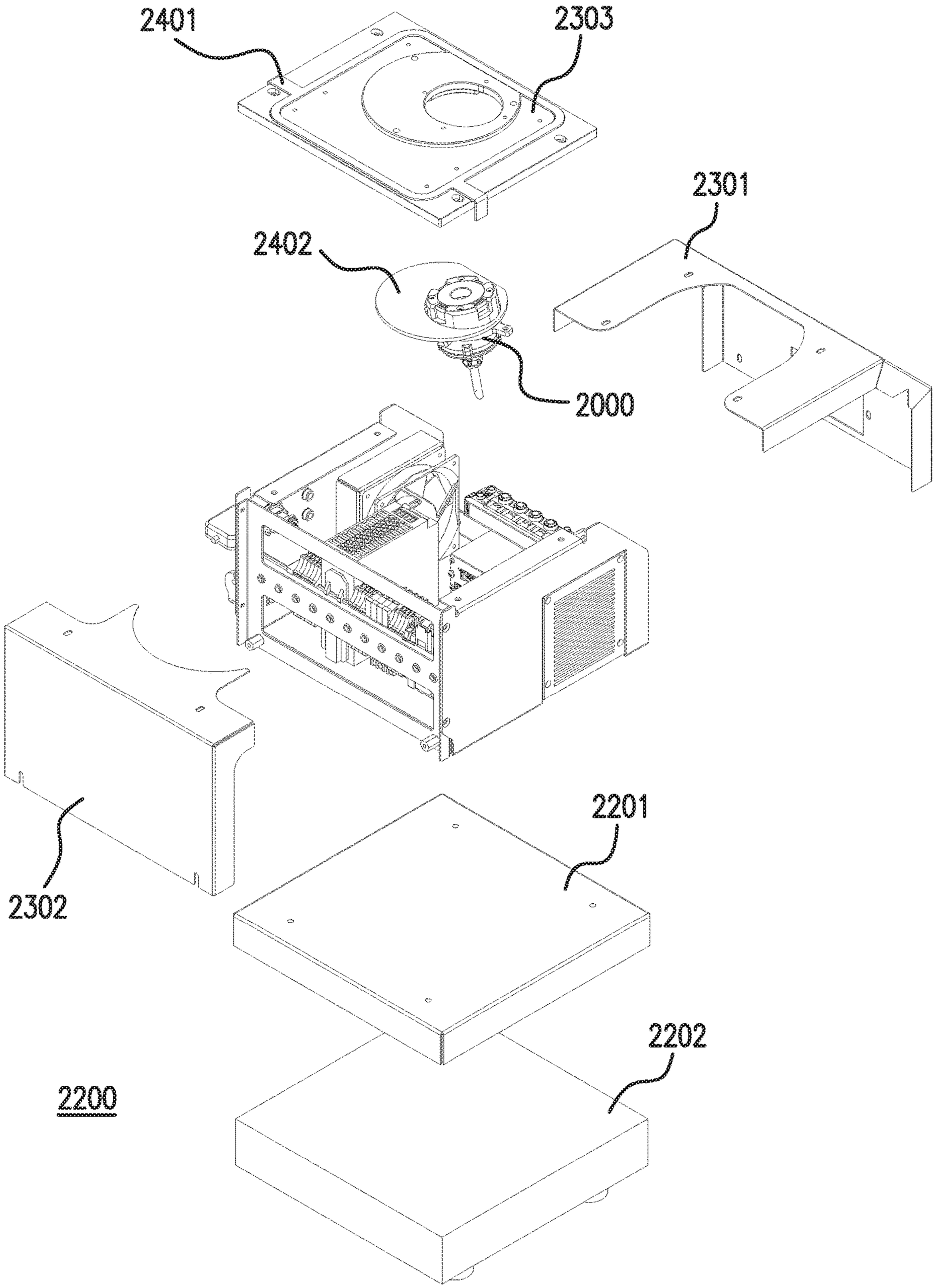


FIG. 13C

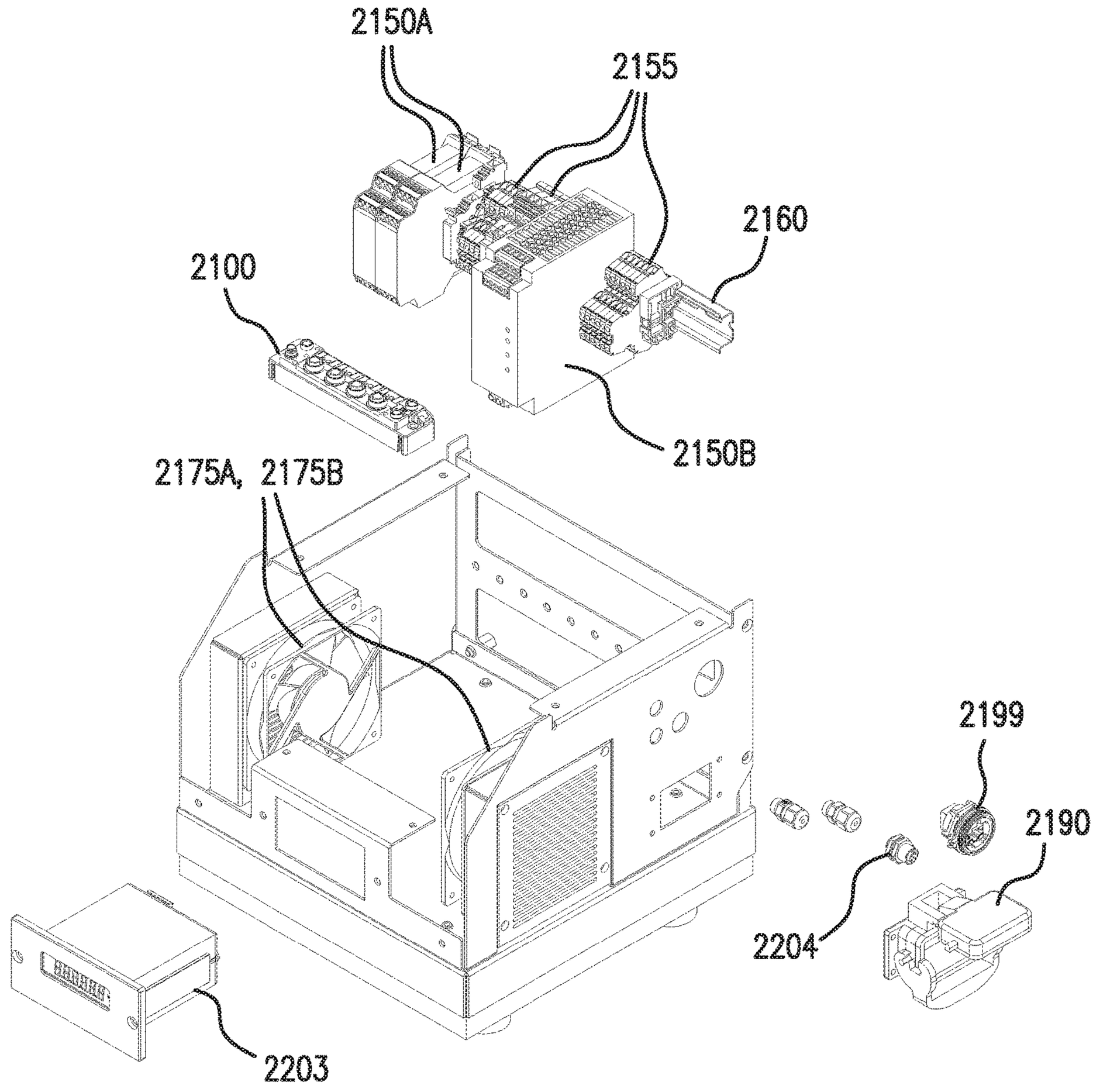


FIG. 13D

MIXER BASE ASSEMBLY FOR MIXING VESSELS AND METHOD OF USE

BACKGROUND OF THE INVENTION

Mixing vessels are mounted to mixer bases for use. However, different mixing vessels have different shapes and/or configurations and can require specialized mixer bases for use.

The present invention provides for ameliorating at least some of the disadvantages of the prior art. These and other advantages of the present invention will be apparent from the description as set forth below.

BRIEF SUMMARY OF THE INVENTION

An embodiment of the invention provides a mixer base assembly comprising (a) a body having (i) an upper end including a mating face for mixing vessel connection; (ii) a lower end including a cavity; (iii) a plurality of side walls; (iv) an inlet port arranged in a side wall; (v) an outlet port arranged in a side wall; (vi) a sampling port arranged in a side wall; (vii) at least one probe port arranged in a side wall; and, (viii) a fluid mixing chamber including a baffle, the fluid mixing chamber having a bottom wall; (b) an impeller seat arranged in the cavity in the lower end of the body; and, (c) a levitating magnetic impeller arranged in the impeller seat, the impeller comprising a magnet, a base, and at least two blades, wherein the at least two blades extend above the bottom wall of the fluid mixing chamber into the fluid mixing chamber.

In another embodiment, a method for mixing fluid comprises connecting a mixing vessel to a mixer base assembly comprising (a) a body having (i) an upper end including a mating face for mixing vessel connection; (ii) a lower end including a cavity; (iii) a plurality of side walls; (iv) an inlet port arranged in a side wall; (v) an outlet port arranged in a side wall; (vi) a sampling port arranged in a side wall; (vii) at least one probe port arranged in a side wall; and, (viii) a fluid mixing chamber including a baffle, the fluid mixing chamber having a bottom wall; (b) an impeller seat arranged in the cavity in the lower end of the body; and, (c) a levitating magnetic impeller arranged in the impeller seat, the impeller comprising a magnet, a base, and at least two blades, wherein the at least two blades extend above the bottom wall of the fluid mixing chamber into the fluid mixing chamber; introducing fluid into the fluid mixing chamber, and rotating the magnetic impeller to mix the fluid in the fluid mixing chamber.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

FIG. **1** is an exploded top view of a mixer base assembly according to an embodiment of the invention, wherein the mixer base assembly comprises a body comprising a baffle, a fluid mixing chamber, two probe ports, a sample port, an inlet port, an outlet port, a vent inlet port, and a vent outlet port, the mixer base also comprising a levitating magnetic impeller, and an interface plate including an impeller seat, two probes, an inlet connector, an outlet connector, a vent filter, a sample port plug including a sealing gasket, a sample port nut, and fluid conduits.

FIG. **2** is a bottom view of the mixer base assembly shown in FIG. **1**.

FIG. **3**A is a top view of a portion of the mixer base assembly shown in FIG. **1**, showing an inlet port communicating with the fluid mixing chamber; FIG. **3**B is a cross-sectional view of the mixer base assembly shown in FIG. **3**A, including an arrow showing the flow path of fluid through the inlet port into the fluid mixing chamber.

FIG. **4**A is a top view of another portion of the mixer base assembly shown in FIG. **1**, showing an outlet port communicating with the fluid mixing chamber; FIG. **4**B is a cross-sectional view of the mixer base assembly shown in FIG. **4**A, including an arrow showing the flow path of fluid through from the fluid mixture chamber and the outlet port.

FIG. **5** shows a cross-sectional view of another portion of the mixer base assembly shown in FIG. **1**, showing a downwardly sloped bottom wall of the fluid mixing chamber and the tips of two probes arranged to sense fluid parameters in the fluid mixing chamber, preferably wherein the slope toward the outlet port minimizes hold-up volume and/or helps create a taller height of fluid with a minimum volume to allow sensing of the fluid parameters. FIG. **5** also shows that the tips of the probes are angled downwardly into the fluid mixing chamber.

FIG. **6** is a partial cross-sectional view of another portion of the mixer base assembly shown in FIG. **1**, showing a vent filter inlet port, a vent filter outlet port, a vent filter communicating with the vent filter outlet port, and fluid conduits.

FIG. **7** is a top perspective view of the interface plate shown in FIG. **1**, also showing the impeller seat.

FIG. **8** is a partial top view of the mixer base assembly shown in FIG. **1**, showing the body including the baffle, and the impeller.

FIGS. **9**A, **10**A, **11**A, and **12**A show embodiments of the mixer base assembly connectable to a variety of mixing vessels, wherein the mixer base assembly is docked into a hardware system (shown in FIGS. **13**A-**13**D) containing electronics and a drive unit to rotate the impeller.

FIG. **9**A shows an embodiment of the mixer base assembly connectable to a commercially available rigid mixing vessel, including a threaded mounting ring that can be threaded to the bottom of the mixing vessel and mated (e.g., by pins or screws) to the mating face of the mixer base assembly; FIG. **9**B shows an enlarged view of the threaded base of the mixing vessel and the mounting ring, FIGS. **9**C and **9**D show, respectively, a cross-sectional view, and a bottom perspective view, of the mounting ring.

FIG. **10**A shows an embodiment of the mixer base assembly connectable to a custom molded rigid mixing vessel; FIG. **10**B shows an enlarged view of the mounting flange at the bottom of the mixing vessel and the mating face of the mixer base assembly, wherein they can be mated together (e.g., by pins or screws, or welded); and FIG. **10**C shows a perspective bottom view of the mounting flange at the bottom of the mixing vessel.

FIG. **11**A shows an embodiment of the mixer base assembly connectable to a flexible mixing vessel (a biocontainer) arranged in a tote, including upper and lower sanitary flanges and a tri-clamp; FIG. **11**B shows an enlarged view of the upper sanitary flange and the tri-clamp; and FIG. **11**C shows an exploded view of the upper sanitary flange, the tri-clamp, and the lower sanitary flange (that can be mated, e.g., by pins or screws, or injection molded as part of the body) to the mating face of the mixer base assembly.

FIG. **12**A shows an embodiment of the mixer base assembly connectable by an adapter to a custom vacuum formed mixing vessel having halves welded together, wherein the vessel can be rigid or flexible; also showing a mating flange connectable to the bottom of the mixing vessel and an adapter for connecting the mating flange to the mixer base assembly; FIG. **12**B shows an enlarged view of the mating

flange and adapter, FIG. **12**C shows top perspective views of the mating flange, adapter, and a sealing ring providing a seal between the adapter and the mating face of the mixer base assembly; and FIG. **12**D shows a bottom perspective view of the sealing ring.

FIG. **13**A shows an illustrative hardware system, FIG. **13**B shows a front partially disassembled view of the hardware system shown in FIG. **13**A, FIG. **13**C shows a rear partially disassembled view of the hardware system shown in FIG. **13**A, and FIG. **13**D shows an internal view of the hardware system shown in FIG. **13**A.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with an embodiment of the invention, a mixer base assembly is provided comprising (a) a body having (i) an upper end including a mating face for mixing vessel connection; (ii) a lower end including a cavity; (iii) a plurality of side walls; (iv) an inlet port arranged in a side wall; (v) an outlet port arranged in a side wall; (vi) a sampling port arranged in a side wall; (vii) at least one probe port arranged in a side wall; and, (viii) a fluid mixing chamber including a baffle, the fluid mixing chamber having a bottom wall; (b) an impeller seat arranged in the cavity in the lower end of the body; and, (c) a levitating magnetic impeller arranged in the impeller seat, the impeller comprising a magnet, a base, and at least two blades, wherein the at least two blades extend above the bottom wall of the fluid mixing chamber into the fluid mixing chamber.

In some embodiments, the impeller seat is fluid tightly sealed to the bottom wall of the fluid mixing chamber. Alternatively, it can be included as part of the fluid mixing chamber (e.g., as a single, injection-molded part).

In a typical embodiment, the mixer base assembly includes two probe ports.

In some embodiments, the mixer base assembly further a vent inlet port and a vent outlet port, wherein the vent outlet port is arranged in a side wall of the body. In another embodiment, the vent outlet port is arranged in the body of the mixing vessel.

In a preferred embodiment, the bottom wall of the mixing chamber slopes downwardly toward the outlet port, and in a more preferred embodiment, the mixer base assembly further comprises at least one probe arranged in the at least one probe port, wherein a tip of the at least one probe (where the sensing element is located) is angled downwardly into the mixing chamber. In some embodiments, the mixer base assembly includes two probe ports, and two probes, each arranged in a separate probe port, wherein the tip of each probe is angled downwardly into the mixing chamber.

In another embodiment, a method for using a mixing fluid comprises connecting a mixing vessel to a mixer base assembly comprising (a) a body having (i) an upper end including a mating face for mixing vessel connection; (ii) a lower end including a cavity; (iii) a plurality of side walls; (iv) an inlet port arranged in a side wall; (v) an outlet port arranged in a side wall; (vi) a sampling port arranged in a side wall; (vii) at least one probe port arranged in a side wall; and, (viii) a fluid mixing chamber including a baffle, the fluid mixing chamber having a bottom wall; (b) an impeller seat arranged in the cavity in the lower end of the body; and, (c) a levitating magnetic impeller arranged in the impeller seat, the impeller comprising a magnet, a base, and at least two blades, wherein the at least two blades extend above the bottom wall of the fluid mixing chamber into the fluid mixing chamber; introducing fluid into the fluid mixing chamber, and rotating the magnetic impeller to mix the fluid in the fluid mixing chamber.

Embodiments of the method can further comprise, for example, measuring or detecting a parameter of the fluid in the fluid mixing chamber (e.g., measuring the pH and/or the conductivity of the fluid) and/or sampling the fluid in the fluid mixing chamber and/or venting air from the mixer base assembly.

Advantageously, embodiments of the present invention provide a "clever base" that can be used with a variety of mixing vessels having different shapes and/or configurations. Homogenized mixing of a wide range of liquid volumes (e.g, about 35 ml to about 10,000 ml) and/or a liquids having wide range of viscosities (e.g., about 1 to about 25 Centipoise (cP)) can be achieved while minimizing or eliminating splashing, foaming, and/or vortexing of the liquids. Moreover, the use of a levitating magnetic impeller significantly reduces shear force, and eliminates rubbing of parts, thus reducing or eliminating particle shed that could contaminate the fluid.

Embodiments of the invention can be used with low volume mixing vessels, and if desired, can be connected to aseptic sampling devices (manual or automatic). If the mixing vessel does not have a vent filter, embodiments of the invention can include connection for a vent filter to maintain sterility and equilibrium of pressures within the system.

Preferably, the mixer base assembly is single-use.

Each of the components of the invention will now be described in more detail below, wherein like components have like reference numbers.

FIG. **1** is an exploded top view of an embodiment of the mixer base assembly according to the invention, wherein the mixer base assembly **500** is part of a mixing base system **1000**.

The illustrated embodiment of the mixer base assembly **500** comprises a body **550** having an upper end **571** including a mating face **575** for mixing vessel/mixing vessel adapter connection; a lower end **572** including a cavity **557**; a plurality of side walls (**4** side walls **551**A, **551**B, **551**C, **551**D are illustrated; an inlet port **501** (shown in more detail in FIG. **3**B) arranged in a side wall **551**A (also showing an inlet port fitting **501**A arranged in the inlet port); an outlet port **502** (having an entrance **502'** and an exit **502"**) (the inlet and outlet ports can be separate components installed in the body or included in the body as a single injection molded part) passing through a different side wall **551**C (also showing an outlet port fitting **502**A arranged in the outlet port **502** as it passes (exits at **502"**) through the side wall); a sampling port **507** arranged in a side wall **551**D (the illustrated port having external threads); at least one probe port arranged in a side wall **551**C (two probe ports **518**, **519** are illustrated, in some embodiments, the ports having internal threads, and probe adapters **818**B and **819**B have external threads, as well as o-rings (o-rings not shown)); and, a fluid mixing chamber **530** including a baffle (or vortex breaker) **525**, the fluid mixing chamber having a bottom wall **531** with a through hole **532**; an interface plate **600** comprising an impeller seat **615**, wherein the interface plate is arranged in the cavity **557** in the lower end of the body **572**, the interface plate also including a top surface **601**, a bottom surface **602** (for docking to the drive unit), a spindle **610**, and a lip **612** wherein the impeller seat and lip are fluid tightly sealed to the bottom wall of the fluid mixing chamber through the through hole **532** (alternatively, the impeller seat can be included as part of the fluid mixing chamber); and a levitating rotating magnetic impeller **650** arranged in the

impeller seat, the impeller comprising a base **652** including a magnet and having a central vertical opening **653** (for the spindle **610**, providing an axis about which the impeller rotates) and at least two blades (four blades **651**A, **651**B, **651**C, **651**D are illustrated), wherein the blades extend above the bottom wall of the fluid mixing chamber into the fluid mixing chamber. As shown in more detail in FIG. **5**, preferably, the bottom wall of the mixing chamber slopes downwardly toward the entrance **502'** of the outlet port.

As shown in FIGS. **3**A-**3**B, fluid is preferably directed via the inlet port **501** to a lower part of the fluid mixing chamber to minimize splashing upon entry, and as shown in FIGS. **4**A-**4**B, the outlet port **502** is positioned at a low point in the bottom wall and passes through the side wall to aid in full draining of the fluid mixture chamber.

In the illustrated embodiment shown in FIG. **1**, the mixer base assembly **500** comprises a baffle (or vortex breaker) **525** in the fluid mixing chamber **530** which is advantageous for minimizing or eliminating splashing, foaming, and/or vortexing of the liquids.

Optionally, as shown in FIGS. **1** and **6**, if a mixing vessel to be attached to the mixer base assembly does not include a vent, the mixer base assembly can further comprise a vent inlet port **511** (also showing a vent inlet port fitting **511**A arranged in the vent inlet port) and a vent outlet port **512** (also showing a vent outlet port fitting **512**A arranged in the vent outlet port), wherein the vent outlet port is arranged in a side wall of the body **551**A, and the vent port is in communication (e.g., via a conduit **924**) with a vent filter **912**. A variety of vent filters are known in the art and are commercially available. The fittings **511**A, **512**A, conduit **924**, and filter **912** can be included with an embodiment of the mixer base assembly, or can be included with an embodiment of the mixing base system.

If desired, embodiments of the mixing base system **1000** or the mixer base assembly can include a sampling arrangement **700** comprising a sample port plug **707** and sample port nut **707**A, wherein the sample port plug **707** can be arranged in the sampling port **507**. In some embodiments, the sampling arrangement is for use with a threaded connection such as, for example, a DN **25** threaded connection. If desired, an autosampling system can be installed through the sampling port **507** and/or manual sampling can be carried out through outlet port exit **502"**. Illustratively, samples can be taken offline to measure parameters that the probes are not reading or to confirm a probe reading or to calibrate a sensor.

Additionally, or alternatively, embodiments of the mixing base system **1000** or the mixer base assembly can include a connector system **900** comprising an inlet connector **201** and an outlet connector **202**, such as aseptic connectors. A variety of connectors, including aseptic connectors, are commercially available, from, for example, Pall Corporation (Port Washington, N.Y., e.g., KLEENPAK® PRESTO); Cole-Parmer (Vernon Hills, Ill.); and Eldon James (Denver, Colo.).

Embodiments of the mixing base system or the mixer base assembly further comprise at least one probe **800**, typically, two probes **818**, **819** (in some embodiments probe adapters **818**B and **819**B are used to connect the probes to the probe ports), wherein FIG. **5** also shows the tips of two probes **818**A, **819**A arranged to sense fluid parameters of fluid in the fluid mixing chamber, preferably wherein the slope toward the outlet port minimizes hold-up volume (sometimes referred to as "carry-over volume") and/or helps create a taller height of fluid with a minimum volume to allow sensing of the fluid parameters. The Figure also shows that the tips of the probes are angled downwardly into the fluid mixing chamber. Advantageously, this allows positioning the tips as low as possible, and certain probes need to be positioned a few degrees above horizontal to operate correctly.

A variety of probes are suitable for use in embodiments of the invention, and are commercially available. Suitable probes include, for example, pH probes, conductivity probes, temperature sensors, dissolved oxygen probes, and cell counters.

The body can be fabricated from any suitable rigid impervious material, including any impervious thermoplastic material, which is compatible with the fluid being processed. For example, the housing can be fabricated from a metal, such as stainless steel, or from a polymer. In a preferred embodiment, the body is injection molded. The adapter plate is preferably plastic, and cannot be a magnetic material.

The mixer base assembly is connectable to a variety of mixing vessels (e.g., as shown in FIGS. **9**A, **10**A, **11**A, and **12**A).

FIG. **9**A shows an embodiment of the mixer base assembly connectable to a commercially available rigid mixing vessel **1500**A having threads **1501** at the bottom, allowing connection with a threaded mounting ring **1502** (having threads **1502**A) that can be threaded to the bottom of the mixing vessel and mated (e.g., by pins or screws) to the mating face of the mixer base assembly; FIG. **9**B shows an enlarged view of the threaded base of the mixing vessel and the mounting ring, FIGS. **9**C and **9**D show, respectively, a cross-sectional view, and a bottom perspective view, of the mounting ring **1502**.

FIG. **10**A shows an embodiment of the mixer base assembly connectable to a custom molded rigid mixing vessel **1500**B having a base **1510** and a mounting flange **1511**; FIG. **10**B shows an enlarged view of the mounting flange **1511** at the bottom of the mixing vessel and the mating face of the mixer base assembly, wherein they can be mated together (e.g., by pins or screws); and FIG. **10**C shows a perspective bottom view of the mounting flange **1511** at the bottom of the mixing vessel.

FIG. **11**A shows an embodiment of the mixer base assembly connectable to a custom formed flexible mixing vessel (a biocontainer) **1500**C arranged in a tote **1507**, including a clamping arrangement **1525** comprising upper and lower sanitary flanges **1526**A, **1526**B, and a tri-clamp **1527**; FIG. **11**B shows an enlarged view of the upper sanitary flange **1526**A and the tri-clamp **1527**; and FIG. **11**C shows an exploded view of the upper sanitary flange **1526**A, the tri-clamp **1527**, and the lower sanitary flange **1526**B (that can be mated, e.g., by pins or screws) to the mating face of the mixer base assembly.

FIG. **12**A shows an embodiment of the mixer base assembly connectable by an adapter to a custom vacuum formed mixing vessel **1500**D having halves welded **1517**A, **1517**B together, wherein the vessel can be rigid or flexible; also showing a mating flange **1518** connectable to the bottom of the mixing vessel and an adapter **1519** for connecting the mating flange to the mixer base assembly; FIG. **12**B shows an enlarged view of the mating flange **1518** and adapter **1519**, FIG. **12**C shows top perspective views of the mating flange **1518**, adapter **1519**, and a sealing ring **1521** providing a seal between the adapter and the mating face of the mixer base assembly; and FIG. **12**D shows a bottom perspective view of the sealing ring **1521**.

Mixing vessels can be docked to a variety of drive systems. Drive systems include a motor, an input/output

(TO) module, a power supply, fans, wiring and connectors, and, optionally, a weighing system, arranged in a housing.

FIGS. **13**A-**13**D show an illustrative drive system **2500** comprising a motor **2000** (shown in FIGS. **13**B and **13**C); an I/O module **2100**, DC-DC converters **2150**A, **2150**B and terminal blocks **2155** (mounted to a rail **2160**), inlet and outlet fans **2175**A, **2175**B (FIG. **13**D), a power receptacle **2190**; a weighing system **2200** (shown including a weighing system cover **2201** and a weighing system load cell **2202** (FIGS. **13**B and **13**C), as well as a weighing system display **2203** and weighing system connector **2204** (FIG. **13**D).

The illustrated housing **2300** includes a front cover **2301**, a rear cover **2302**, a top cover/mixer base support **2303**, and a chassis **2304**.

FIG. **13**C shows a top cover gasket **2401** is mounted on top of the top cover/mixer base support **2303**, and a mixer base assembly gasket **2402** is mounted on top of the motor **2000**.

A variety of motors for magnetically levitating and spinning the impellers are known in the art. Commercially available motors include those available from Pall Corporation (Port Washington, N.Y.; e.g., LEVMIXER® SYSTEM) and Levitronix GmbH (Zurich, Switzerland).

The mating face of the mixer base assembly can be adapted for connection to a variety of size, shape, and/or type of mixing vessels, and the bottom surface of the interface plate can be adapted for docking to a variety of drive systems. In some embodiments, components and/or processes such as screws, pins, bolts, mounting rings, adapters, o-rings (with or without grooves or channels in the mating face), sanitary gaskets, and/or ultrasonic welding can be used for efficient connection. FIGS. **9**B-**9**D, **10**B-**10**C, **11**B-**11**C, and **12**B-**12**D show exemplary components and processes for connection, and FIG. **13**C shows exemplary components for docking.

The following examples further illustrate the invention but, of course, should not be construed as in any way limiting its scope.

Example 1

This example demonstrates the quick (less than 60 seconds) homogenous mixing time and low carry-over volume (less than 20 mL) when using a mixer base assembly according to an embodiment of the invention with a variety of mixing vessels and fluid viscosities.

An embodiment of a mixer base assembly as generally shown in FIG. **1** is connected to mixing vessels and drive units as generally shown in FIGS. **9**A, **10**A, **11**A, and **12**B.

In each experiment, the fluid volume is 100 mL, and the impeller speed is 700 rpm. In one set of experiments, the fluid viscosity is 1 cP, in the other set of experiments, the fluid viscosity if 25 cP.

The homogenous mixing time is conducted via additions of acids and bases, and time recorded to stability of pH, defined as a 10 second period of time with a pH change of <0.1. At 1 cP, the mixing time for the acid is 14 seconds, and the mixing time for the base is 13 seconds. At 25 cP, the mixing time for the acid is 24 seconds, and the mixing time for the base is 31 seconds.

The carry-over volume for the mixing vessel shown in FIG. **9**A is 7 mL; for FIG. **10**A, 11 mL; for FIG. **11**A, 4 mL, and for FIG. **12**A, 15 mL.

Example 2

This example demonstrates the quick (less than 60 seconds) homogenous mixing time and low carry-over volume (less than 20 mL) when using a mixer base assembly according to an embodiment of the invention with a variety of mixing vessels and fluid viscosities.

This example is similar to Example 1, with the exception that the fluid volume is 10,000 mL (100:1 turndown ratio), and the impeller speed is 5000 rpm.

As with Example 1, in one set of experiments, the fluid viscosity is 1 cP, in the other set of experiments, the fluid viscosity if 25 cP.

At 1 cP, the mixing time for the acid for the mixing vessel shown in FIG. **9**A is 20 seconds, for FIG. **10**A is 35 seconds, for FIG. **11**A is 9 seconds, and for FIG. **12**A is 29 seconds. The mixing time for the base for each of these mixing vessels is 31 seconds, 44 seconds, 45 seconds, and 34 seconds, respectively.

At 25 cP, the mixing time for the acid for the mixing vessel shown in FIG. **9**A is 33 seconds, for FIG. **10**A is 22 seconds, for FIG. **11**A is 39 seconds, and for FIG. **12**A is 32 seconds. The mixing time for the base for the mixing vessel shown in FIG. **9**A is not stable after 1197 seconds (it is believed the shape and footprint of the vessel does not allow good mixing at high viscosity); for FIG. **10**A is 35 seconds, for FIG. **11**A is 34 seconds, and for FIG. **12**A is 34 seconds.

As with Example 1, the carry-over volume for the mixing vessel shown in FIG. **9**A is 7 mL; for FIG. **10**A, 11 mL; for FIG. **11**A, 4 mL, and for FIG. **12**A, 15 mL.

All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

The use of the terms "a" and "an" and "the" and "at least one" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The use of the term "at least one" followed by a list of one or more items (for example, "at least one of A and B") is to be construed to mean one item selected from the listed items (A or B) or any combination of two or more of the listed items (A and B), unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein.

Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

The invention claimed is:

1. A mixer base assembly comprising:

(a) a body having:

(i) an upper end including a mating face for mixing vessel connection;

(ii) a lower end including a cavity;

(iii) a plurality of side walls comprising a first side wall, a second side wall, a third side wall, and a fourth side wall;

(iv) an inlet port arranged in the first side wall;

(v) an outlet port arranged in the third side wall;

(vi) a sampling port arranged in the fourth side wall;

(vii) at least one probe port arranged in the third side wall; and,

(viii) a fluid mixing chamber including a baffle, the fluid mixing chamber having a bottom wall;

(b) an impeller seat arranged in the cavity in the lower end of the body; and,

(c) a levitating magnetic impeller arranged in the impeller seat, the levitating magnetic impeller comprising a magnet, a base, and at least two blades, wherein the at least two blades extend above the bottom wall of the fluid mixing chamber into the fluid mixing chamber.

2. The mixer base assembly of claim **1**, further comprising a vent inlet port and a vent outlet port, wherein the vent outlet port is arranged in the first side wall of the body.

3. The mixer base assembly of claim **2**, wherein the bottom wall of the mixing chamber slopes downwardly in a direction from the inlet port toward the outlet port.

4. The mixer base assembly of claim **3**, further comprising at least one probe insertable into the at least one probe port.

5. The mixer base assembly of claim **3**, further comprising a sampling arrangement comprising a sample port plug and a sample port nut, wherein the sample port plug is insertable into the sampling port.

6. The mixer base assembly of claim **2**, further comprising at least one probe insertable into the at least one probe port.

7. The mixer base assembly of claim **6**, further comprising a sampling arrangement comprising a sample port plug and a sample port nut, wherein the sample port plug is insertable into the sampling port.

8. The mixer base assembly of claim **2**, further comprising a sampling arrangement comprising a sample port plug and a sample port nut, wherein the sample port plug is insertable into the sampling port.

9. The mixer base assembly of claim **1**, wherein the bottom wall of the mixing chamber slopes downwardly in a direction from the inlet port toward the outlet port.

10. The mixer base assembly of claim **9**, further comprising at least one probe insertable into the at least one probe port.

11. The mixer base assembly of claim **10**, further comprising a sampling arrangement comprising a sample port plug and a sample port nut, wherein the sample port plug is insertable into the sampling port.

12. The mixer base assembly of claim **9**, further comprising a sampling arrangement comprising a sample port plug and a sample port nut, wherein the sample port plug is insertable into the sampling port.

13. The mixer base assembly of claim **1**, further comprising at least one probe insertable into the at least one probe port.

14. The mixer base assembly of claim **13**, further comprising a sampling arrangement comprising a sample port plug and a sample port nut, wherein the sample port plug is insertable into the sampling port.

15. The mixer base assembly of claim **1**, further comprising a sampling arrangement comprising a sample port plug and a sample port nut, wherein the sample port plug is insertable into the sampling port.

16. The mixer base assembly of claim **1**, wherein the base of the levitating magnetic impeller includes a central vertical opening for a spindle, the mixer base assembly further comprising an interface plate arranged in the cavity in the lower end of the body, the interface plate including the spindle, wherein the levitating magnetic impeller rotates around the spindle.

17. A method for mixing fluid, the method comprising:

connecting a mixing vessel to a mixer base assembly comprising (a) a body having (i) an upper end including a mating face for mixing vessel connection; (ii) a lower end including a cavity; (iii) a plurality of side walls comprising a first side wall, a second side wall, a third side wall, and a fourth side wall; (iv) an inlet port arranged in the first side wall; (v) an outlet port arranged in the third side wall; (vi) a sampling port arranged in the fourth side wall; (vii) at least one probe port arranged in the third side wall; and, (viii) a fluid mixing chamber including a baffle, the fluid mixing chamber having a bottom wall; (b) an impeller seat arranged in the cavity in the lower end of the body; and, (c) a levitating magnetic impeller arranged in the impeller seat, the levitating magnetic impeller comprising a magnet, a base, and at least two blades, wherein the at least two blades extend above the bottom wall of the fluid mixing chamber into the fluid mixing chamber; and,

introducing fluid into the fluid mixing chamber, and rotating the levitating magnetic impeller to mix the fluid in the fluid mixing chamber.

18. The method of claim **17**, further comprising measuring the pH and/or conductivity of the fluid in the fluid mixing chamber.

19. The method of claim **18**, further comprising sampling the fluid in the fluid mixing chamber.

20. The method of claim **17**, further comprising sampling the fluid in the fluid mixing chamber.

21. The method of claim **17**, wherein the base of the levitating magnetic impeller includes a central vertical opening for a spindle, the mixer base assembly further comprising an interface plate arranged in the cavity in the lower end of the body, the interface plate including the spindle, wherein the levitating magnetic impeller rotates around the spindle.

* * * * *